

NASA Contractor Report 185194

Unified Aeroacoustics Analysis for
High Speed Turboprop Aerodynamics and Noise

Volume IV - Computer User's Manual for UAAP Turboprop Aeroacoustic Code

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United Technologies Corporation
Hamilton Standard Division
Windsor Locks, Connecticut

May 1991

Prepared for
Lewis Research Center
Under Contract Number NAS3-23720



National Aeronautics and
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SUMMARY

This is the 4th volume of a 5 volume report on the aerodynamics and aeroacoustics of advanced turboprops. It explains the use of the UAAP (Unified Aero-Acoustic Program) code for predicting overall propeller performance and for predicting steady and unsteady airloading, wakes, and noise of the blades. The aerodynamic and acoustic methods are based on linear pressure potential theory with corrections for non-linearity associated with axial mass flux induction and vortex lift on the blades. Theory is derived in Volume I (NASA CR-4329) and compared with experimental results in Volume III (NASA CR-185193). Other volumes in the report are Volume II, which gives theory for shielding of propeller sources by a swept wing in compressible flow, and Volume V, which presents theory for acoustic shielding by a fuselage boundary layer. Theory in the latter 2 volumes is not included in the code described herein.

Major sections of this volume include a general code overview, descriptions of the input and output, a general system description, and a listing of error codes.

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SECTION 1 INTRODUCTION

This is Volume IV of a five volume report. The five volume report presents a unified theory for aerodynamics and noise of advanced turboprops. Aerodynamic topics include calculation of performance, blade load distribution, and non-uniform wake flow fields. Blade loading can be steady or unsteady due to fixed distortion, counter-rotating wakes, or blade vibration. The aerodynamic theory is based on the pressure potential method and is therefore basically linear. However, non-linear effects associated with finite axial induction and blade vortex flow are included via approximate methods. Acoustic topics include radiation of noise caused by blade thickness, steady loading (including vortex lift), and unsteady loading. Shielding of the fuselage by its boundary layer and the wing are treated in separate analyses.

The Unified Aero-Acoustic Program (UAAP) code discussed in this volume calculates the airloads on a single rotation Prop-Fan, or propeller, and couples these airloads with an acoustic radiation theory, to provide estimates of near-field or far-field noise levels. The steady airloads can also be used to calculate the non-uniform velocity components in the propeller wake.

The airloads are calculated using a three dimensional compressible panel method which considers the effects of thin, cambered, multiple blades which may be highly swept. These airloads may be either steady or unsteady. The acoustic model uses the blade thickness distribution and the steady or unsteady aerodynamic loads to calculate the acoustic radiation.

This report constitutes the users manual for the UAAP code. The report is divided into five sections:

- General Code Description
- Input Description
- Output Description
- System Description
- Error Codes

The user must have access to IMSL10 libraries (MATH and SFUN) for numerous calls made for bessell functions and matrix inversion. For plotted output users must modify the "dummy" calls to plotting routines included in the code to system-specific calls appropriate to the user's installation.

Instructions for use of the separate code for prediction of boundary layer refraction are included in Volume V which describes that code.

SECTION 2 GENERAL CODE DESCRIPTION

The UAAP code is divided into six major functional modules. Each functional module performs a unique task and consists of one or more subroutines. Generally, the routines in a functional module are unique to that module although, interpolation routines, integration routines and others may be required in another functional area. The functions performed by these six modules are:

- 1) Blade Geometry Generation - Inputs the propeller/blade shapes and transcribes them into the format required by the other portions of the code.
- 2) Propeller Flow Field - Inputs the propeller axial velocity flowfield (supplied by the user) and transcribes that flowfield into the format required by other portions of the code; interpolates the propeller flowfield at the control points required by the aerodynamic portion of the code.
- 3) Compressible Panel Method Aerodynamics - Calculates the steady or unsteady aerodynamic loads on the blade.
- 4) Vortex Flow Aerodynamics - Calculates the change in the airloads due to leading edge and tip edge vortex effects produced by the steady compressible panel method.
- 5) Acoustic Analysis - Calculates the near field or far field propeller noise.
- 6) Wake Calculations - Calculates the wake caused by viscous and potential effects.

Options have been incorporated in the code to allow restart of the code at two points:

- 1) Restart of Compressible Panel Method Aerodynamics
- 2) Restart of Acoustic Analysis

The restart capabilities are detailed in the Input Description section of this manual.

This code involves contributions from several disciplines in propeller design, including performance, acoustics, and structures. Each of these disciplines has its own coordinate system and these are supported whenever possible. However, this does bring about some conflict and the user is cautioned to

reference this users manual for proper interpretation of the coordinate systems.

Figure 1 presents an overview of the UAAP code. As shown, two parallel paths exist within the code: a steady airload computation, and an unsteady airload computation. These computations can only be performed with separate executions of the code.

The steady airload calculation path shows the computation of the loading kernel matrix and thickness vector, and the storage of those quantities in an external file. The stored loading kernel and thickness vector are used to compute the blade loading including the vortex loading. 2-D airfoil tables are used to obtain the viscous losses. The blade loading is then used to obtain blade wake profiles, overall aerodynamic performance, and noise.

The unsteady airload calculation follows a path similar to that for calculation of the steady airloads. As shown in figure 1, the unsteady loading does not include vortex loading or viscous drag, and produces only an unsteady acoustic calculation. Complex values of the inlet downwash vector are required as input for the unsteady calculation.

Steady and unsteady airload and acoustic calculations must be run separately, thus, output from the unsteady calculation doesn't contain the steady loading effect. Also, unsteady loads must be run one harmonic at a time.

SECTION 3 INPUT DESCRIPTION

The primary input mode is expected to be a predefined input dataset. Upon program execution the primary input file, file #5, is immediately read and echoed to both the primary output file, file #6, (to obtain a complete copy of the input on the output file) and to a scratch file, file #11. All subsequent primary input is obtained by reading file #11.

No other input files are required by the code except as the user may define for restart capabilities. Several scratch files are generated by the program; they are defined in the section "UAAP System Description."

There are many input values which act as tolerances on iterations, or convergence criteria. These have been defaulted within the code to "recommended" values. Although they explicitly appear in the input description, they need not be input. Input data which need not be input appears at the end of each section, and the input location number appears within parentheses.

The next sections present a description of all the input necessary to run the code.

Commands

The code is command driven. Commands are used to identify the input sections, the input, and to execute various functions of the code. Sub-commands are used to execute options within functions. The general input format of the command is:

(starting in column 1)

COMMANDX(SUBCOMMD) where "COMMANDX" is an 8 character word, including trailing blanks, and "SUBCOMMD" is also an 8 character word, including trailing blanks.

Load

Some commands require that numerical input must be read in next. For this purpose a location-specified free field input routine is used which reads between columns 1 and 72. Locations for input are indicated by "L" followed by a number indicating the desired start of a location.

Some of the location specified input controls integration mesh sizes, Fourier series convergence, and other program tolerances. These locations have been identified by parenthesis () around the location number and can usually be ignored by the user. However, if these values are input, the parenthesis () should be omitted from the location field.

Input for this "LOAD" format is illustrated below:

(starting in column 1)

```
C THIS IS AN OPTIONAL COMMENT RECORD (or Records)
L 10 1.1 2 3.5
C THIS IS ANOTHER OPTIONAL COMMENT RECORD (or Records)
  12.7 13.1
L 91 6.5
END
```

This will cause the locations shown below to have the following values:

LOCATION	VALUE
10	1.1
11	2.0
12	3.5
13	12.7
14	13.1
91	6.5

Notes: "Scientific notation" is not allowed, e.g. 2.1 E+03 is not allowed. Implied repetitions are not allowed, e.g. 3*2.1 is not allowed. The "END" record is required to terminate each entry into the LOAD routine.

Command Summary

A list of accepted commands are shown below. Since this is a command driven code, command order is important, and therefore the commands are listed below in the required logical sequence for execution.

HEADER	-	Input page header cards
RUNPARMS	-	Input flight parameters
AIRPARMS	-	Input options for 2-D drag look-up.
BLADEGEO	-	Input propeller/blade geometry (2-D, RXY or XYZ coordinates).
LSTPARMS	-	Input options to panel aero code.
NOIZPARM	-	Input options to the noise portion of the code.
VELGRADS	-	Input axial velocity field on a defined grid.
VORTPARM	-	Input options to vortex flow calculation.
WAKEPARM	-	Input options to wake calculation.
AEROEXEC	-	Execute the aero code.
WAKEEXEC	-	Execute the wake calculation.
NOIZEXEC	-	Execute the noise portion of the code.
ENDCASE	-	End of input and calculations for the current case.
ENDJOB	-	End of job, terminate the program.

Specific Input Description

Input requirements/options are provided below for each command, in the order listed above.

HEADER:

This command enters page heading records. Records following the HEADER command are sequentially read until an "END" command is found. Up to 10 page heading records may be entered.

RUNPARMS:

This command enters run parameters using "LOAD" format. The location, default, and input descriptions are:

LOC.	Default	Variable	Description
1	0	RUNBUG	Debug Option, 1 turns on.
2	59.0	QDEGF	Ambient temperature, °F.
3	1.0	QRHOR	Ambient density/Sea Level Std. density.
4	0	QADV	Advance ratio, $J = V_o/nD$.
5	0	QMX	Free stream Mach number.

LSTPARMS:

This command enters input options to the panel aero portion of the code using "LOAD" format.

The location, default value and input description are:

(* See Figure 2 for pictorial description)

LOC.	Default	Variable	Description
1	0	ZSTBUG	Debug Option, 1 turns on.
* 2	10	QNCP	Number of chordwise panels (maximum of 20)
* 4	8	QNSM	Number of spanwise modes (maximum of 20)
20	3	QPART1	0 generate K^{-1} and w_T 1 generate K^{-1} and read w_T 2 read K^{-1} and gen. w_T 3 read in K^{-1} and w_T The code requires an inverse kernel matrix (K^{-1}) and a thickness vector (w_T) to obtain the aerodynamic loading on the

blade.₁
 The K^{-1} matrix and W_1 vector
 require a significant amount
 of CPU time, and an option to
 utilize a previously generated
 K^{-1} matrix and W_1 vector has
 been incorporated into the code.

See SECTION V.

21	0	QQ	Order of unsteady loading harmonic, = 0 for steady loading.
22	0	QK	Number of circumferential modes for unsteady loading, = 0 for steady loading
28	2	QNB OPT	= 1 for supersonic leading edge element, use when supersonic flow expected at leading edge. = 2 for subsonic leading edge element
29	10	QITNON	Max number of non-linear iterations. = 0 for linear calculation.
*	101 .2, .35, .45, .55, .65, .75, .85, .95	QZAR	Spanwise locations of control point radius. The number of these must agree with QNSM, fraction of RTIP.
*	141 .5, .5	QCONTP	Chordwise location of control points within each panel normalized to the panel width. There must be QNSM of these.
181	.4, .4	QCHW	Width for chordwise averaging of downwash, normalized to panel width. There must be QNSM of these input.
351	0, 0	QWMU	Downwash vector for unsteady loading calculation. These can be obtained from Appendix I, equation (8). The values of QWMU must be input sequentially starting in location 351, as real part, imaginary part for each control point across the 1st spanwise

station, and then proceeding outward along the blade span. Thus, there must be (QNCP*QNSM) pairs of values input for QWMU.

The following input locations may be ignored.

(3)	.02	QDR	Radial extent of singular integral at control point radius for wake calculation radius.
(5)	1024	QN	Number of points in FFT for terms in kernel integration, max. of 2048, must be a power of 2.
(6)	.004	QDELTA	Axial step size for FFT.
(7)	4	QMODOP	Spanwise mode shape option (use default value).
(8)	.0001	QTOLF	Tolerance for W (omega) integration.
(9)	.001	QTOLT	Tolerance for other integrations.
(10)	.005	QTOLS	Tolerance for summations
(11)	20	QMM1	Loop limit for harmonic summation in wake kernel.
(12)	30	QMM2	Loop limit for harmonic summation in bound kernel.
(13)	10	QMM3	Loop limit for harmonic summation in thickness vector.
(14)	8	QITABK	File number allocated for K-1 storage.
(15)	9	QITABT	File number allocated for W_t (thickness vector) storage.
(16)		QINT4	Not currently used.
(17)	0	QPRINT	Additional debug print - not recommended.
(18)	0	QPRIN1	Additional debug print - not recommended.

(19)	0	QPRIN2	Additional debug print - not recommended.
(23)	.025	QKDOWN	Radial step size for non-singular bound kernel
(24)	.010	QKSTART	Width of singular region for bound kernel integration
(25)	5	QMM4	Loop limit for summation in sound power calculation.
(26)	.9	QMBLEN	Trailing edge effective Mach number for blending to supersonic trailing edge elements.
(27)	1024	QNO	Number of points in FFT integration for n = 0 term in kernel, max =2048.
(221)	.002	QINMES	Step size for radial integration in wake kernel.

BLADEGEO:

This command enters the propeller/blade geometry using the "LOAD" format. For any propeller and flight condition, the shaft power required, and the thrust produced by the propeller are a function of the blade angle. In using this code it is recommended that the blade angle be adjusted so that the power or thrust calculated by this program matches a desired value. (see Volume III, page 6.2 for further explanation).

Three subcommands exist to allow input of the geometry in different forms:

BLADEGEO(2-DCOORD), BLADEGEO(RXYCOORD), and BLADEGEO(XYZCOORD). These are described below.

BLADEGEO(2-DCOORD):

This form of the blade geometry is expected to be the most widely used. Input takes the form of the spanwise variation of thickness ratio, chord/diameter ratio, twist, airfoil section designation and stacking axis coordinates. This command (sub-command) will calculate the blade surface coordinates and interpolate these into a form required by the other parts of the program. To assure that there are no errors in the blade output description only a limited amount of extrapolation of the input blade coordinates is allowed. Thus, it is best to provide input stations, X, and streamline angles, SLA, which will define the root and tip sections of the blade such that the output stations, ZBLDST, can be interpolated and not extrapolated. The code requires exactly ten (10) inputs defining X. The input described below is illustrated in Figures 3 and 4.

Note that there are empty locations in the input. These are not used by the program.

LOC.	Default	Variable	Description
1	0	BLDEBUG	Debug option, 0 is off, 1 is on.
31	0	BLADE	Number of blades
32	0	D	Propeller diameter, ft.
33	0	SCO	Propeller hub/tip ratio
41-50	0	X	Spanwise input stations, 10 are required, fractions of RTIP.
51-60	0	HOB	Spanwise airfoil maximum thickness/chord ratio.
61-70	0	BOD	Spanwise chord/diameter variation.

71-80	0	CLD	Spanwise variation of design lift coefficients.
81-90	0	DTHET	Spanwise twist variation. Twist should be input such that the 75% radius twist is 0, degrees.
347	0	THTDES	The 75% radius value of blade angle at which the blade is to be "designed", degrees.
348	0	THTCUT	The 75% radius value of blade angle at which this calculation is to be run, degrees.
<p>Note: Propeller blades are assumed to be "designed" at one value of blade angle. The input values of thickness/chord, chord/diameter, camber, twist and stacking line are assumed to be defined at the value of blade angle in Location 347.</p> <p>Location 348 defines the blade angle at which this calculation is to be run.</p>			
381-390	0	SLA	Spanwise variation of streamline angle, degrees. Blade airfoil sections are assumed to be on cones which approximate the streamlines thru the propeller. This input is the 1/2 cone angle, positive as shown in Figure 3.
711-720	0	XSWP	Spanwise variation of X coordinate of mid-chord stacking line, fraction of Rtip, see figure 4.
721-730	0	YSWP	Spanwise variation of Y coordinate of mid-chord stacking line, fraction of Rtip, see figure 4.
731-740	0	ZSWP	Spanwise variation of Z coordinate of mid-chord stacking line, fraction of Rtip, see figure 4.

900	21	ZNPCOV	Number of output stations in the chordwise direction, max 49.
901-949	0., 5.,	PCTCHD	Chordwise location of output stations. Both upper and lower airfoil surfaces are output at the same chordwise locations, % chord.
	10, 15, 20,		
	25, 30, 35,		
	40, 45, 50,		
	55, 60, 65,		
	70, 75, 80,		
	85, 90, 95,		
	100		
950	21	ZNIS	Number of output stations in the spanwise direction. max of 49.
951-999	.10, .30,	ZBLDST	Spanwise location stations at which the blade surface will be defined, radius ratios, r/RTIP.
	.40, .50,		
	.55, .60,		
	.65, .70,		
	.75, .80,		
	.825, .85,		
	.875, .90,		
	.925, .95,		
	.96, .97,		
	.98, .99		
	1.0		

The following input locations may be ignored.

(346)	2	SWPOPT	Input sweep option. The default value is required.
(349)	1	ZKCUT	Type of airfoil section defined 0 planar, 1 conical, use default, 2 cylindrical
(741-751)	1	BAFL	Integer characterizing the 2-D airfoil at each spanwise station. Only NACA 16 series airfoils can be generated with this deck.

BLADEGEO(RXYCOORD):

An optional method for input of the blade geometry has been , provided. This form allows for up to 50 input stations. Additionally, it requires a table of the displacement of the mean camber line from the chord line.

This option requires that the blade sections being described be on cylinders whose axis is the centerline of rotation. The input is illustrated in Figures 5, 6 and 7.

LOC.	Default	Variable	Description
1	0	BLSBUG	Debug Option, 0 is off, 1 is on.
2	0	STANO	Number of spanwise input stations, max of 50
3	0	PCTNO	Number of chordwise input stations, max of 50
4	0	DIAMET	Propeller diameter, ft.
5	0	SPINNER	Propeller hub/tip ratio
6	0	BLADES	Number of propeller blades
51 -100	0	CTSTA	Spanwise input stations, r/R_{TIP}
101-150	0	PCTCD	Chordwise input stations, %chord

At each spanwise station

151-200	0	THKOB	Maximum blade thickness, fraction of chord.
201-250	0	CHDOD	Blade chord, fraction of diameter.
251-300	0	CAMBR	Equivalent NACA Series 16 camber. Obtained by taking the non-dimensional maximum height of the blade mean camber line / .05515 , fraction of chord.
301-350	0	TWIST	Blade section chord angle, deg.
351-400	0	XMC	X-coordinate of mid-chord stacking line, fraction of R_{tip} .
401-450	0	YMC	Y-coordinate of mid-chord stacking line, fraction of R_{tip} .

451-500	0	ZMC	Z-coordinate of mid-chord stacking line, fraction of Rtip.
501-550	0	XSLA	Streamline angle, deg. This is the flow angle relative to the centerline of rotation, and is used in the sweep angle calculation.
1001	1		Required value, to set up table for interpolation.
1002	1		Required value, to set up table for interpolation.

Blade mean camber line displacement table.

1003	0	PCTND	Number of chordwise points in mean camber line displacement table.
1004	0	STAND	Number of spanwise points in mean camber line displacement table.
1005	0	CAMLN	Ascending array of chord fractions, PCTND values. Followed immediately by :
1005 + PCTND	0	CAMLN	Ascending array of spanwise radius, fraction of Rtip. Starting after last input location, STAND values. Followed immediately by :
1005 + PCTND+STAND	0	CAMLN(I,K) I=1,STAND K=1,PCTND	Array (PCTND*STAND) of mean camber line displacements from chord line at each radial station, at 1st chordwise location, fraction of chord. This is followed by a similar array for the 2nd chordwise location, and continues thru the PCTND chordwise location.

BLADEGEO(XYZCOORD):

This form of blade geometry inputs the blade description in XYZ coordinates of each blade surface. Figure 8 illustrates the coordinate system used. Note that this XYZ coordinate system is different than the 2-D or the RXY system.

LOC.	Default	Variable	Description
1	0	BLDEBUG	Print option, 0 is minimal 1 is additional.
2	0	DIAME	Propeller Diameter, ft.
3	0	SPINN	Hub to tip ratio.
4	0	BLADE	Number of blades
5	0	STINN	Number of radial stations in input.
6	0	CDINN	Number of chordwise stations in input.
7	0	STOUTN	Number of output radial stations needed to define the blade.
8	0	CDOUTN	Number of output chordwise stations needed to define the blade.
51	0	STOUTV	Values of radial stations, fraction of radius.
101	0	CDOUTV	Values of chordwise stations fraction of chord.

An "END" record is required to terminate the "LOAD" input. The "END" record is immediately followed by the xyz coordinates of the blade as follows:

For each of the STINN radial input stations the following input records are required:

- a) A label record
- b) For each of the CDINN chordwise input stations the X, Y, & Z coordinates of the face (pressure) side of the blade are input. With one set of X, Y, Z, coordinates in free field format per record. The units are inches.

c) Another label record

d) For each of the CDINN chordwise input stations the X, Y, & Z coordinates of the camber (suction) side of the blade surface are input. With one set of X, Y, Z coordinates in free field format per record. The units are inches.

VELGRADS:

This command will input or initialize the axial velocity ratio at the propeller. These ratio may be due to the spinner-hub and or nacelle effects on the freestream flow, but the result must appear to the code as an axisymmetric flowfield.

LOC.	Default	Variable	Description
1	0	V1BUG	Debug option
2	0	V1OPT	Velocity ratio input option, 0 : initialize velocity field to 1.0, fraction of freestream velocity. No further input is required. 1 : input the velocity ratio.

For option V1OPT=1. only:

The axisymmetric velocity ratio is input on a grid of radial and axial points which encompass the blade outer boundaries. The flowfield values are interpolated at specific "nodal" points required by the code.

3	0	VINRD	Number of radial stations in grid.
4	0	VINAS	Number of axial stations in grid.
5	0	VIVRF	Reference velocity, by which local velocities are normalized, same units as VIRD, VIVV, and VIAX.
6	0	VITIP	Reference radius, by which local radii are normalized, same units as VIRD and VIAX.
7	0	VICLL	Centerline location. The axial location of the blade pitch axis is assumed to be 0. This value will be subtracted from the input values of VIAX after input so that the axial location of the blade centerline will be at 0. Same units as VIAX.

The following inputs are repeated for each of the axial stations in the grid, (K=1,VINAS).

25	0	VIRD(I,K) I=1,VINRD	Radial locations of 1st set of up-stream grid points, same units as VITIP.
25+		VIVV(I,K) I=1,VINRD	Velocities at VIAX(I), VIRD(I), same units as VIVRF.
25+		VIAX(I,K) I=1,VINRD	Axial locations of VIVV(I), same units as VITIP.

WAKEPARM:

This command provides input parameters to the propeller wake calculation procedure. This input is used in both the performance calculations, and in the "Wake" calculation option. The variables used for propeller efficiency and wake calculation are listed below.

LOC.	Default	Variable	Description
1	0	WAKBUG	Debug option, 1 print WAKEPARM input data. 0 do not print data.
6	1	YIPLLOT	Wake output, 1 is on, 0 is off.
8	1	YNPSKN	Skin friction drag . 1 : included, 0 : not included.
20	0	YIPRT	Output option: 0 : no output 1 : Vr/V & Vx/V 2 : Fluctuating lift
23	0	YIVWK	The viscous wake shape is described by 1 of 3 options 0 : gauss pulse 1 : cosine squared 2 : cosine
25	11	YNORPE	No. of output radii.

751	.24,.35,YROUTP .45,.55, .65,.75, .80,.85, .90,.95, .98	Output radii, r/Rtip.
-----	---	-----------------------

The following input locations may be ignored.

(2)	.05	YK	Spanwise integration mesh size, fraction of radius.
(9)	.0001	YTOL	Fourier series sum convergence tolerance
(10)	99	YMM1	Max. no. of Fourier coeff. to calculate, max. of 99.
(12)	.001	YTOL1	Tolerance for high frequency form of Fourier coeff.
(13)	0	YLASTM	Last Fourier coeff. for detailed output.
(16)	0.7	YZO	Origin of special routine for interpolation of circulation curve.
(17)	0.5	YZNORM	Circulation curve normalizing factor
(18)	1.0	YAOPT	0 to not iterate on induced angle
(21)	0	YMM2	Turns on diagnostic print for Fourier coeff. up to YMM2 when YIPRT = 2.

The following inputs are required in addition to the above if wakes are to be calculated.

LOC.	Default	Variable	Description
			Output radii are divided into those within the tip radius, YNOR, and those beyond the tip radius, YNPX.
4	0	YNOR	Number of output radii which are less than or equal 1.0 (within tip radius).
5	0	YNPX	Number of output radii which are greater than 1.0 (outside of tip).
50	0	YXNCS	No. of output axial locations, max of 10 at each radius.
51	0	YXMMU	No. of Fourier coeff. used in calculation of chordwise wake component.
52	0	YXMMV	No. of Fourier coeff. used in calculation of radial wake component.
53	0	YXMMW	No. of Fourier coeff. used in calculation of downwash wake component.
351		ROUT	Output radii, fraction of radius. There should be YNOR+YNPX of these.
701	0	YARRY(I,K) I=1,YXNCS	Output axial locations, fraction of radius, for 1st output radius. There should be YXNCS of these.
711	0	YARRY(I,K) I=1,YXNCS	Output axial locations, fraction of radius, for

2nd output radius. There should be YXNCS of these.

721	0	YARRY(I,K) I=1,YXNCS	Output axial locations, fraction of radius, for 3rd output radius. There should be YXNCS of these.
-----	---	-------------------------	--

where $K = 1, YNOR + YNPX$

The following input location may be ignored.

(54)	0.01	YFPHW	Width of averaging function for wake calculations = X/R_{TIP} .
------	------	-------	---

AIRPARMS:

This command will input options which are used to obtain the 2-D airfoil drag from built-in tables of lift and drag coefficients.

LOC.	Default	Variable	Description
1	0	AIRBUG	Debug Option, 1 to print

The following input locations may be ignored.

(2)	24	AIRNUM	2-D Airfoil data pack number wanted for this run. Currently, only NACA 16 is available in this code.
(3)	5	AIRTYP	0 : Isolated 2D airfoil 1 : Isolated 2D airfoil w/cascade corr. 4 : Isolated 2D airfoil w/sweep corr. 5 : Isolated 2D airfoil w/sweep & cascade.
(13)	0	AIRCOR	0 : no drag correction input 1 : drag correction input
(15)	0	CDMLT	2D drag multiplier, used if AIRCOR = 1.
(17)	0	DCDT	2D drag increment, used if AIRCOR = 1.

CDMLT and DCDT are used to alter the drag of the stored airfoil data. They may be used to simulate another airfoil, to account for a rough airfoil or provide a better match with test efficiency.

$$C_d = C_{d0} * CDMLT + DCDT$$

NOIZPARM:

This command will input the options which are used to control the acoustic calculations.

NOTES: B is number of blades, M is noise harmonic order
B * ZMMAX must be less than 1001
MX is flight Mach number (may not be 0 for near field calculation)

LOC.	Default	Variable	Description
1	0	ZNZDBG	Debug option : 0 no print; 1 print input parameters 2 print file 50 input
2	0	ZNFIND	0 for far field theory 1 for near field theory
3	1	ZMMAX	Max noise harmonic order to calculate.
4		ALT	Distance from prop axis to observer, ft.
9		ZNX	Number of axial directivities for noise calculations (20 max)
10	1	ZXORX1	Axial directivities are 1 : visual or 0 : retarded.
11		X1	Visual positions of observer along axis (+ ahead of prop),ft. (calculated if X is input).
		or	
31		X	Retarded positions of observer, ft. (calculated if X1 is input).

59	1	ZIBLW	1 to add boundary layer and wake displacement to geometry of blade trailing edge. 0 for comparison with other predictions.
70	0	PHI	Azimuthal observer directivity angle. 0 is when the blade lies in the plane of the observer and prop axis

PHI - Azimuthal observer directivity angle for unsteady loading, degrees, PHI increases in the direction of rotation, zero corresponds to the phase reference position for calculation of unsteady airloads. Thus, the observer position is specified relative to the unsteady flow field reference.

The following input locations may be ignored.

(51)	10	ZJMINI	With ZNJ1, controls chordwise integration mesh
(52)	8	ZNJ1	# chordwise points = $ZJMINI + M + B * ZNJ1$, 1001 max pts
(53)	10	ZJMIN2	Used with ZNJ2, controls spanwise integration mesh
(54)	10	ZNJ2	# spanwise points is JMAX (must be less than 2001) which is calculated : if $ZNJ2 > 0$ $JMAX = ZJMIN2 + M * B * ZNJ2$; if $ZNJ2 < 0$, $JMAX = ZJMIN2 - ZNJ2$ if $ZNJ2 = 0$, $JMAX = ZJMIN2 + ZNJ2$ points/phase cycle.
(55)	6	ZIW	Output file #
(56)	1	ZSTART	Start harmonic order
(57)	1	ZMINC	Increment in harmonic order

(58)	2	ZLHSOR	Indicates what type of unsteady flow 1 = blade wakes, 2 = flowfield,
(60)	0	ZPRUNS	If not 0 print diagnostic unsteady loading noise table
(61)	0	ZITRAP	If not 0 max diagnostic print
(62)	0	ZNFOUT	If not 0 print harmonic table to file # ZNFOUT, allocate appropriate
(64)	0	ZKXTND	See note below.
(65)	10	ZKMIN	See note below.
(66)	10	ZOMEGA	See note below.
(67)	0	ZIPDET	If not 0, print tables of amplitude and phase vs. radius. ZIPDET is the highest order to be printed.
(68)	0	ZLHRMP	If not 0, print load harmonic summation terms (far-field option only).
(71)	1	ZNAIR	Code for airfoil thickness distribution (specify for all radial stations): 1 = series 16 3 = series 64 5 = series 65 7 = biconvex parabolic (analytic) 8 = 4 digit series

ZKXTND, ZKMIN, and ZOMEGA :

In the near field option, the program evaluates a Fourier transform numerically using rectangular integration. The range for this frequency integration is $1/(1+MX)$ to $1/(1-MX)$, where MX is the flight Mach number. The number of steps in the integration range determines the trade-off between precision and running time. The integrand is typically a fluctuating quantity whose rate of

oscillation dI/dw , is computed by the program as a function of several factors such as harmonic order, Mach number, and observer position. To achieve uniform precision over a range of conditions, the program determines the number of points, kk , in the frequency integration range from 2 input numbers: the first is the minimum points in the range ($ZKMIN$) and the second is the number of mesh points per oscillation of the integrand ($ZOMEGA$). The number of integration points is then $kk = ZKMIN + ZKOMEA * dI/dw$. Default values are $ZKMIN = 10$ and $ZOMEGA = 10$, which numerical tests indicate gave a reasonable compromise between precision and running time. If the user wishes to experiment, he can override either of the 2 default values. Reducing the number of points will reduce running time and storage requirements, but also reduce the precision of the calculation. Determining the satisfactory level of tradeoff between precision and running time for other than the defaults is up to the user. In some cases a significant contribution to the noise can be caused by frequencies outside the range of frequency integration noted above. To account for this, $ZKXTND$ points are included outside both the upper and lower bounds of the integration. If $ZKXTND$ equals zero then it is automatically computed by the program, otherwise the input value of $ZKXTND$ is used. However, $kk + 2 * ZKXTND$ must be less than 401. If this is not true then the code will reduce $ZMMAX$ by one until this condition is met.

VORTPARM:

This command inputs the options which are available to control the Vortex Flow Aerodynamic calculations.

LOC.	Default	Variable	Description
1	0	VTXDBG	Debug option if = 0 no input print, if = 1 input printed
2	1	DOLEAD	If = 1 then calculate additional lift due to leading edge vortex.
3	1	DOSIDE	If = 1 then calculate additional lift or radial force due to tip edge flow.
4	1	DOAUGL	If = 1 then calculate additional lift due to leading edge vortex shed over aft portion of blade at the tip (augumented lift).
5	.97	ZAUGFF	Radius at which augmented lift acts, r/R_{tip} .
6	0	TIPLOR	Indicates whether tip edge flow results in extra lift (0) or radial force (1).

TIPLOR is set by the user to determine the type of edge flow.

0 for separated tip flow, where the tip vortex gives extra flow at the tip;

1 for attached tip flow which produces a radial tip edge force.

AEROEXEC(PRNTCASE):

This command (Subcommand) will process all of the input and execute the code to the point where the Compressible Panel Method prints the data it has received. The aerodynamic calculations will not be performed. This is useful in verifying the input before doing the actual aero calculations.

AEROEXEC(EXECCASE):

This command (Subcommand) will process all of the input and execute the aerodynamic calculations.

NOIEXEC(EXECCASE):

This command will execute the noise calculation section of the code. This should be placed after the AEROEXEC record.

WAKEEXEC(EXECCASE):

This command will execute the potential and viscous wake calculations. This should be placed after the AEROEXEC or NOIEXEC record.

ENDCASE:

This command signifies the end of all commands for the current case, and is required.

ENDJOB:

This command will terminate execution, and is required.

SECTION 4 OUTPUT DESCRIPTION

This section presents a description of the output from the UAAP program and includes output print from AEROEXEC (the panel code performance calculation), WAKEEXEC (the wake velocity calculation), and NOIZEXEC (the noise calculation).

The debug option described under the various input section commands controls the scope of output, and are either 0. (the default), 1., or 2., yielding additional output. Most pages have a page title followed by the label records entered in the input HEADER section. The page title consists of : 1) a brief description of the page contents. This is followed by, after the first colon (;), the subroutine name which is doing the printing of this page, 2) the input command option currently in effect, 3) the time and date at the start of the run, and 4) the program/version identification.

Output Description (DEBUG = 1)

OUTPUT:

The output starts with an echo of the input data set, which is discussed in the input description, and shown in Figures 9-13.

RUNPARMS:

The debug option of 1. will print the page shown in Figure 14, which shows the input parameters, defined in the input section, along with the location number and the input or defaulted value.

NOIZPARM:

The debug option of 1. will print the page shown in Figure 15 which shows the input parameters, defined in the input section.

VORTPARM:

The debug option of 1. will print the page shown in Figure 16 which shows the input parameters, defined in the input section.

LSTPARMS:

Selecting the debug option, LSTBUG = 1., will print additional input definition as shown in Figure 17, which lists the available input options, their location number and the selected or defaulted values. Refer to the input description for more input detail.

AIRPARMS:

Figure 18 presents the additional output for debug = 1. Again, the parameters are defined in the input section. A few lines of airfoil description are given, defining the airfoil selected, used to determine profile drag.

WAKEPARM:

If a debug option of 1. is chosen, an additional input table, Figure 19 is obtained. Refer to the input section for parameter definition.

VELGRADS:

Figure 20 is a sample of output using debug = 1, which labels the input for this section.

BLADE GEOMETRY OUTPUT

BLADEGEO:

DEBUG = 1. in the BLADEGEO section of input yields an additional page of input definition, given in Figure 21. Definitions of the parameters follow:

<u>Parameter</u>	<u>Description</u>
DEBUG	Debug option for additional print default 0. Off, or 1.
BLADN	Number of blades
DIAMETER	Propeller diameter, feet
SCO	Inner-most blade station at 50% chord
SWEEP TYPE	Defined in input as SWPOPT
DESIGN ANGLE	Defined in input as THTDES
RUNNING ANGLE	Defined in input as THTCUT
TYPE CUT	Defined in input as ZKCUT
X	Station radius/blade radius
T/B	Maximum blade thickness/blade chord
B/D	Blade chord/propeller diameter
CAMBER	Design lift coefficient
DELTA THETA	Blade twist, from plane of rotation, degrees
XSWP	Defined in input
YSWP	Defined in input
ZSWP	Defined in input

AIRFOIL TYPE	Defined in input as BAFL
NO. OF % CHORD	Defined in input as ZNPCOV
LIST OF % CHORD	Defined in input as PCTCHD
NO. OUT STATIONS	Defined in input as ZNIS
LIST - STATIONS	Defined in input as ZBLDST

AERODYNAMIC OUTPUT

AEROEXEC: Figure 22A summarizes the flight condition, blade geometry and other parameters that are used in the panel code performance calculation (AEROEXEC). Definition of the parameters in Figure 22A follows:

<u>Parameter</u>	<u>Description</u>
TEMP, DEGF	Ambient temperature, °F
RHO/RHO STD	Ambient density/standard density
SPEED OF SOUND	Ambient speed of sound, fps
ADVANCE RATIO	Flight velocity/(rps*diameter)
FLIGHT MACH NO.	Flight Mach number
FLIGHT SPD FPS	Flight velocity, fps
RPM	Propeller, rpm
TIP HEL. MACH	Mach number based on resultant flight and tip speed velocities
START BLENDING	Defined in input as QMBLEN
DIAMETER	Propeller diameter, feet
NO. BLADES	Blade number
NO. INPT STA.	Number of input stations
FREQ. OF UNST.	Defined in input as QQ
NO. NODAL DIA.	Defined in input as QK
K - DOWN	Defined in input as QKDOWN

K - START	Defined in input as QKSTART
INPUT STATIONS	Blade radial stations/blade radius
B/D	Blade chord/propeller diameter
TOTAL TWIST	Operating twist from plane of rotation, degrees
MCA/D	Distances from pitch change axis to blade mid-chord point along the helix/propeller diameter (ref. Fig 3.1 of Vol.I)
FA/D	Perpendicular distance from helix to the intersection of the blade mid-chord and mid-camber point/diameter (ref. Fig 3.1 of Vol.I)
T/B	Max. blade thicknesses/blade chord
CLD	Blade design lift coefficients
SWEEP	Sweep angles between 50% mid chord line and resultant inflow velocity

Another output table is given in Figures 22B and C. This is a table of the camber height/blade chord as a function of local radius/blade radius and local chord/blade chord which has been calculated from the input in BLADEGEO. The propeller driveshaft power which has been converted to acoustic energy has been calculated and is listed on figure 23 in coefficient form with the heading "SOUND POWER".

LSTBUG = 1. also prints intermediate non-linear iteration steps, as shown in Figures 23. The iteration continues (and has been omitted herein) until CPFRONT, the power coefficient ceases to change, Figure 24. The parameters shown are:

$$\text{SOUND POWER} = \frac{\text{acoustic power loss}}{(\text{diam})^5} (\text{density} * (\text{rev/unit time})^3)$$

$$\text{CP} = \frac{\text{power}}{(\text{density} * (\text{rev/unit time})^3 * (\text{diameter})^5)}$$

$$\text{CT} = \frac{\text{thrust}}{(\text{density} * (\text{rev/unit time})^2 * (\text{diameter})^4)}$$

$$\text{EFFICIENCY} = \text{apparent efficiency} = \text{CT} * \text{advance ratio} / \text{CP}$$

VORTEX OUTPUT

VORTEXEC: The output from the vortex performance calculation is given in Figure 25 and includes four pages of output described below.

The first page, Figure 25A defines the selected operating condition:

<u>Parameter</u>	<u>Description</u>
FLIGHT MACH #	The flight Mach number
TIP ROT. MACH #	The tip rotational Mach number
ADVANCE RATIO	The advance ratio
TEMP. DEG F	Ambient static temperature, °F
DENSITY RATIO	Density ratio, ambient density/standard level density
# RADIAL STATIONS	The number of output radial stations
# CHORD- WISE STATIONS	The number of chordwise stations, QNCP
# SPAN- WISE MODES	The number of spanwise modes or control points, QSMN
MODOPT	The spanwise mode type option, defined in LSTPARMS input as QMODOP
NBOPT	The lead-edge panel load shape option, defined in LSTPARMS input as QNBOPT

The second output page Figure 25B describes blade geometry parameters and some force coefficients from the potential flow lifting surface calculation. A brief description of the tabulated parameters follows.

<u>Parameter</u>	<u>Description</u>
THETA 3/4	The blade angle at the .75 radius

# Blades	Number of propeller blades
DIAMETER	Propeller diameter, feet
SPINNER CUTOFF	Innermost airfoil shaped blade radius/propeller radius.
RADIAL STATION	The selected output spanwise radial station/propeller radius.
CHORD/DIAMETER	Local chord/propeller diameter for each radial station.
THICK/CHORD	Local section maximum blade thickness local blade chord.
MID-CHORD COORDINATES	The coordinates, at 50% chord are defined in figures 5, 6 & 7.
XMC	Local radial coordinate/propeller radius.
YMC	Local inplane coordinate/propeller radius.
ZMC	Local axial coordinate/propeller radius. (positive downstream)
FACE ALINE	Perpendicular distance from the local mid-chord location to the local helical plane/propeller diameter.
MID-CHORD ALINE	Distance along the local helical plane to the local mid-chord location/propeller diameter.
MID-CHORD SWEEP	Local sweep angle between the mid chord line and the resultant velocity
L.E. SWEEP	Local sweep angle between the lead edge and the resultant velocity, degrees.
ALPHA 2-D	Two-dimensional angle of attack used to determine airfoil tabulated C_p , degrees.
ALPHA 3-D	Angle difference between the twist angle and the advance angle, both defined below, degrees.
L.E. CAMBER	Lead edge camber angle (angle between camber line at the lead edge and the chord line), degrees

L.E. A.O.A Lead edge angle of attack
 (ALPHA 3-D minus camber angle), degrees.

ADVANCE ANGLE Angle between the resultant velocity
 neglecting induced flow and the local
 rotational velocity, degrees.

TWIST ANGLE Local blade angle measured from plane of
 rotation, degrees.

**Note : all lift and drag coefficients are
 non-dimensionalized by $qr \cdot b \cdot dr$ where :**

qr - dynamic pressure of the resultant
 velocity
 b - blade chord defined above
 dr - unit spanwise length

CDLST The drag coefficient obtained from the
 airfoil tables at ALPHA 2-D
 Where drag is a downstream force along the
 advance angle

CDMIN Minimum drag coefficient.

C_{DO} Drag coefficient at lift coefficient = 0

CDCLVD Drag to lift ratio

CDUAP2 Total drag coefficient equal to :
 $CDLST + CDCLVD \cdot CLLST$

CLLST Lift coefficient calculated from lifting
 surface

L.E.K., MAG Flat plate load coefficient where,
 $L.E.K., MAG = \Delta C_p \cdot (fc / (1 - fc))^{.5}$
 ΔC_p = the differential pressure
 coefficient between blade upper and lower
 surfaces and
 fc = fractional chord length

L.E. THRUST Component of leading edge suction parallel
 to leading edge camber line equal to
 $Thrust / (qr \cdot b \cdot dr)$
 qr - dynamic pressure of the resultant
 velocity
 b - blade chord defined above
 dr - unit spanwise length

DESIGN CL	Local blade design lift coefficient (camber)
1	0.00
2	0.00
3	0.00
4	0.00
5	0.00
6	0.00
7	0.00
8	0.00
9	0.00
10	0.00
11	0.00
12	0.00
13	0.00
14	0.00
15	0.00
16	0.00
17	0.00
18	0.00
19	0.00
20	0.00
21	0.00
22	0.00
23	0.00
24	0.00
25	0.00
26	0.00
27	0.00
28	0.00
29	0.00
30	0.00
31	0.00
32	0.00
33	0.00
34	0.00
35	0.00
36	0.00
37	0.00
38	0.00
39	0.00
40	0.00
41	0.00
42	0.00
43	0.00
44	0.00
45	0.00
46	0.00
47	0.00
48	0.00
49	0.00
50	0.00
51	0.00
52	0.00
53	0.00
54	0.00
55	0.00
56	0.00
57	0.00
58	0.00
59	0.00
60	0.00
61	0.00
62	0.00
63	0.00
64	0.00
65	0.00
66	0.00
67	0.00
68	0.00
69	0.00
70	0.00
71	0.00
72	0.00
73	0.00
74	0.00
75	0.00
76	0.00
77	0.00
78	0.00
79	0.00
80	0.00
81	0.00
82	0.00
83	0.00
84	0.00
85	0.00
86	0.00
87	0.00
88	0.00
89	0.00
90	0.00
91	0.00
92	0.00
93	0.00
94	0.00
95	0.00
96	0.00
97	0.00
98	0.00
99	0.00
100	0.00

Parameter

POT LIFT

L.E. VORTEX

TIP VORTEX

AUGUMENTED VORTEX

TOTAL LIFT

POT + LE VORT

POT + SE VORT

POT + AUGVORT

POT DRAG

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POT + LE VORT	Sum of POT DRAG and drag coefficient from the lead edge vortex
POT + SE VORT	Sum of POT DRAG and drag coefficient from the tip vortex
POT + AUG VORT	Sum of POT DRAG and drag coefficient from augmented normal coefficient
TOTAL DRAG	Total drag coefficient

The final page, Figure 25D, of AEROEXEC output shows the spanwise change in power coefficient (DCP/DX), thrust coefficient (DCT/DX) and efficiency (DETA/DX) for each of the components in lift and drag discussed above, and then finally the integrated, power coefficients, thrust coefficients and efficiency.

WAKE OUTPUT

WAKEEXEC: The output from the wake velocity calculation Figure 26A presents a table of the following velocity parameters, defined in the velocity diagram of Figure 26B.

<u>Parameter</u>	<u>Description</u>
PHI	Cylindrical coordinate angle, degrees. Zero degrees at the sheet.
Vo	Freestream velocity
Uo	Local resultant velocity.
U	Induced velocity in resultant velocity direction (+ direction shown in diagram).
W	Induced velocity perpendicular to resultant velocity direction (+ direction shown in diagram)
Vx	Induced velocity in axial direction (+ direction shown in diagram).
VT	Induced velocity in tangential direction (+ direction shown in diagram).
RADIUS	Local radius/propeller radius at which the wake velocity is calculated.
XMBAR	Axial distance/propeller radius from the propeller pitch change axis (+ downstream)
POTENTIAL	Potential flow velocity component.

NUMBER OF HARMONICS - Maximum noise harmonic order to calculate
 (Expression) PTS CHORDWISE - Number of chordwise integration
 mesh points

DIRECTIVITY POINTS ANALYZED - Number of axial directivities

NUMBER OF RADIAL STATIONS ON BLADE

(Expression) PTS/CYCLE RADIAL INT - Number of radial integration
 mesh points

(Expression) PTS/CYCLE W INT - Number of frequency integration
 mesh points in the range
 $1/1+MX$ to $1/1-MX$ (used in the
 near field calc. only). MX is
 the flight Mach number.

W EXTEND POINTS - Number of points in the frequency
 integration outside
 the range $1/1+MX$ to $1/1-MX$

NEAR FIELD ANALYSIS INDICATOR - 0 for far-field,
 1 for near-field calc.

DETAIL PRINT INDICATOR - Number of harmonics for which a detailed
 print will be obtained (set by ZIPDET)

QUADRUPOLE TERM CALC. CODE - Not 0 to calculate "instant"
 quadrupole noise.

The observer directivity points lie on a line parallel to the
 propeller rotation axis. The distance between the axis of
 rotation and the axial observer line is the altitude or sideline
 distance. The relationships between the visual and retarded
 distances and angles are shown in Figure 27B.

The addition of the boundary layer and wake displacement
 thickness to the airfoil thickness is indicated by the next line.

AZIMUTHAL DIRECTIVITY ANGLE - see Figure 27C for a description of
 this variable.

On the next page (Figure 28) is a header indicating the beginning
 of the noise calculation results.

At this point a description of the detailed printout (obtained when ZIPDET is not 0) is appropriate (see figure 29A). For each harmonic up to ZIPDET, a table of information is presented as a function of radial position. This includes the following information:

<u>Parameter</u>	<u>Description</u>
RADIAL STATION INDEX	Counter for radial elements
RANGE	Inner and outer limits of radial element
KX	Chordwise wave number
KY	Normal-to-chord wave number
PHASE LAG DUE TO	Blade sweep
PHASE LAG DUE TO OFFSET	From the helical surface
SUM OF SOURCES	Total noise including radial load and "instant" quadrupole
MONOPOLE	Blade thickness (plus boundary layer and wake displacement) sources.
DIPOLE	Lift, drag, and radial loading sources.
QUADRUPOLE	Nonlinear sources ("instant" quadrupole)
AMP	Linear noise amplitude scaled to an arbitrary value
PHASE	Relative phase of noise components
RADIAL LOAD	Noise due to radial forces at blade tip
BLADE TOTALS PASCALS (RMS)	Sound pressure levels
DB - NO INTERFERENCE	Noise level neglecting the effects of sweep and offset. This is computed to show how much noise reduction is due to blade sweep and offset. The noise reduction depends on the operating condition as well as the propeller configuration. The noise level neglecting blade sweep and offset is computed by integrating the noise contribution from the spanwise strips using the phase angles PHIO and PHIS (offset and sweep).

DECIBELS	Resultant noise level in dB, including sweep and offset.
----------	--

The following page (Figure 29B) is a summary of the noise calculation results for the first directivity. This type of page is repeated for as many directivities as were requested by the user. The information presented is:

X	Retarded axial position
X1	Visual axial position
THETA	Retarded observer angle
HARMONIC ORDER	Multiple of blade passage frequency
FREQ HZ	Harmonic frequency, Hertz
SUM OF 3 SOURCES	Indicates the total noise for all sources (including blade thickness, boundary layer and wake, lift and drag, quadrupole and radial blade loads).
DB	Noise level, Decibels
PASCALS	Sound pressure level in Pascals
PHASE	Relative phase of the noise component
MONOPOLE	Noise due to blade thickness plus displacement thickness
DIPOLE	Noise due to lift and drag
QUADRUPOLE	Noise due to nonlinear sources (normally not used herein)
RADIAL LOAD	Noise due to tip edge radial forces
INTEGRATION MESHES	Number of points used in integrations
JAMX	Number of radial mesh points
KK	Number of frequency integration points in range from $1/1+MX$ to $1/1-MX$, where MX is the flight Mach number.
KEXTND	Number of points outside the KK range

The FINAL NOISE SUMMARY TABLE (Figure 30) is presented on the next page. The header is repeated at the top of this page, followed by the sideline distance and a table of the axial observer locations. Then the total noise and its components are listed for each directivity.

SECTION 5 SYSTEM DESCRIPTION

Language Requirements

The source programs included in the delivered code are written in the FORTRAN 77 language. This code was originally written on the IBM 3090, and compiled using the IBM LEVEL 1.4.1 (May, 1985) VS FORTRAN compiler. Extensive use of double precision variable typing in the form of DOUBLE PRECISION, REAL * 16, IMPLICIT DOUBLE PRECISION and COMPLEX * 16, along with the implied double precision arithmetic was required on the IBM 3090 to achieve the numerical precision demanded by the analysis methods. The delivered code contains these type statements. However, on the CRAY these double precision statements are "turned off" by use of a compiler option.

Note: REAL *16 and COMPLEX * 16 are not Fortran 77 Statements.

Library Requirements

The IMSL (International Mathematical and Statistical Library Version 10), libraries MATH and SFUN are required by the code. The IMSL single precision library is used by the CRAY version, while, the IBM 3090 requires the IMSL double precision libraries.

The standard FORTRAN library functions are required by this code, and have not been delivered with the code, e.g. COS, SIN, etc.

Subroutine CLOCK, and DATE are CRAY calls to obtain system time and date respectively.

File Allocations

The file requirements are shown in figure 31, "UAAP System File Requirements". Conceptually these files are used in the following manner:

- 5 Input options, specifications, and commands are entered on file 5 by the user.
- 6 Program output file for hardcopy printing. Contents of this file are detailed in the "OUTPUT Description" section of this manual.
- 8 The major amount of CPU time spent by the program involves generating and inverting a matrix, K^{-1} , in the lifting surface aerodynamic section of the code, LSTALS. The K^{-1} matrix is written to file 8, and later re-read by the program. If the user wishes to

save this file after program termination, the user will have to create appropriate machine dependent Job Control Language code to do so. Saving of the K^{-1} matrix will allow other cases to be run with this K^{-1} thus saving CPU time.

- 9 This file contains the "THICKNESS VECTOR" generated by the lifting surface aerodynamic section of the code, LSTALS, it will be read into the program later. As with the K^{-1} matrix on file 8 the user may save the "THICKNESS VECTOR" for future use.
- 11 Subroutine INPTRW reads the entire file 5 and echo's it to the output file 6, and to a temporary storage file 11. File 11 will be rewound and re-read by individual subcommands.
- 44 This file is used to transfer data between the Panel portion of the aerodynamic code and the Vortex calculation portion of the aerodynamic code.
- 50 This file is used to transfer data between the aerodynamic and the noise sections of the code.
- 51 Scratch file, for use by the acoustic portion of the code.
- 52 Scratch file, for use by the acoustic portion of the code.

Input Data Storage Flow Chart

Input data is arranged according to the functional area in which it will be used. Each group of input is read into the functional area in which it is to be used, and is stored in a Fortran Labeled Common. Figure 32 illustrates the functional areas into which input is read, and the name of the Labeled Common in which the data is stored. With the exception of BLDGEM, and VELGRD, no substantial amount of calculations are performed on the input data before storage in the Labeled Common areas. In BLDGEM the input blade geometric description is transformed into a form useable by the other sections of the code, before storage into BLDGEO Labeled Common area. In VELGRD, the input axisymmetric velocity gradients are normalized by the freestream velocity before storage in the V1I1C1 Labeled Common area.

TREE Structure

A tree structure which identifies the calling sequence in the program has been created. The tree structure provides the calling sequences possible during execution, but program options which decide the actual calling sequence during execution are not accounted for.

The number on the left of the tree, Figure 33, indicates the "level" at which the subroutine (whose name appears next to the level number) is called. A brief description of the major subroutines is provided adjacent to the subroutine name.

For example, referring to FIG 33, the MAIN program calls DATE to get the current date, this is a "level 1" call :

MAIN	calls CLOCK to get the current time of day,
MAIN	calls INPTRW to read file 5 and echo the input to file 11.
INPTRW	calls NEWPGI to print a page heading, this is a "level 2" call,
MAIN	calls BLDGEM which is the top level routine for calculating the blade geometry.
BLDGEM	calls EXIT, a System Routine. This call occurs only when a particular error occurs.

Subroutine References

Each subroutine contained in the delivered code has been alphabetically listed in figure 34. Adjacent to the subroutine name is brief description of that subroutine if one exists in the source code. All of the subroutines referenced by that subroutine are listed on the next line adjacent to the word "CALL(S):".

Figure 35 provides an alphabetized list of subroutines, followed by a list of subroutines which call them.

List of Subroutines

Figure 36 provides an alphabetized list of subroutines which include labeled common areas, and the names of the labeled common areas. Subroutines names appear on the left while labeled common areas appear to the right of the colon. Figure 37 is a cross reference of labeled common blocks and subroutines using them. Common block names appear on the left while subroutines in which the common block is used appear to the right of the colon.

SECTION 6 ERROR CODES

This section contains a description of the printed error messages, along with possible causes and remedies in alphabetized order.

"AIRFOIL NO. = ... OFF AIRFOIL DATA AND IOFF ..."

The program obtains profile drag from airfoil data tables as a function of lift, mach number, airfoil thickness ratio, and airfoil chord. This message indicates one or more of the above parameters exceeded the limits of the stored data.

Recommendation : check the output for reasonable values of drag coefficients. Use AIRPARMS inputs CDMULT and DCD to correct unreasonable values.

"AIRFOIL ... OFF AIRFOIL DATA "

Same as above.

"BDS0 ... "

There are a number of errors, generally resulting in program termination, which are associated with the blade geometry generator; these messages are prefaced with BDS0. They arise because the blade surface generated from user input in BLADEGEO was not sufficient to allow intersection with the output stations (conical surfaces) specified in BLADEGEO variable ZBLDST. Solution: The problem can usually be avoided (with only a slight loss in program accuracy) by setting THTDES = THTCUT in BLADEGEO, and assuring that $X(1) < ZBLDST(1)$ and $X(10) > ZBLDST(ZNIS)$ in BLADEGEO input.

"*** CONTROL POINT STATIONS NOT WITHIN ..."

The radial difference between control points, QZAR in LSTPARMS, and ZBLDST in BLADEGEO $> .02$.

Solution : Change the either QZAR or ZBLDST input values.

"FAILED TO CONVERGE ON CL ..."

An iteration failed when trying to obtain the profile drag data from the airfoil tables.

Recommendation : check the output for reasonable values of drag coefficients. Use AIRPARMS inputs CDMULT and DCD to correct unreasonable values.

"FOR OUTPUT POINT NUMBER ..."

Interpolation of the flowfield from VELGRADS is performed in two ways : radial first, axial second, and then axial first, radial second. Usually these interpolations yield the same value of velocity at a

fixed radial and axial location. However, for this point the difference in interpolations exceeded 1 %. Probable cause : the flowfield is not smooth in either or both the radial and axial directions.

"FOR OUTPUT POINT NUMBER ... THE AXIAL ..."

The axial extent of coordinates input into VELGRADS was not sufficient to allow interpolation of the flowfield at either the blade leading or trailing edge.

Solution : add more points to the flowfield input in VELGRADS in the axial direction.

"FOR OUTPUT POINT NUMBER ... THE RADIAL ..."

The radial extent of coordinates input into VELGRADS was not sufficient to allow interpolation of the flowfield at either the blade root or tip.

Solution : add more points to the flowfield input in VELGRADS in the radial direction.

"INVALID INPUT CHARACTER ..."

The load routine has found a character in column 1 which is not an "L", "C", "E", or blank.

Possible causes : "END" record omitted; numeric data in column 1.

"THE INPUT CONTAINS AN UNKNOWN COMMAND ..."

A COMMAND was expected at this point in the input, however, the 8 printed characters do not represent a recognizable command.

Possible causes : mis-spelled command; no "END" record in load format.

COMMAND didn't start in column 1.

"THE INPUT CONTAINS AN UNKNOWN SUBCOMMAND.."

A subcommand was found which didn't match the acceptable subcommands.

Possible causes : incorrect spelling; incorrect placement of parenthesis.

"THE NUMBER OF HEADER CARDS"

More than 10 header records were encountered during processing of the HEADER command.

Possible causes : more the 10 records following the HEADER command; no "END" record after the last header record.

"V1S1X1 DIMENSIONED 20X20 ..."

The flowfield input in VELGRADS was too large; the maximum number of coordinates in the axial or radial direction is 20.

Solution : reduce the number VINRD and/or VINAS to 20.

"***** MM2 AND MM3 MUST BE LESS THAN 100 ..."
See QMM2 and QMM3 limits in LSTPARMS.

"***** NBOPT MUST BE 1 OR 2 ..."
See QNBOPT limits in LSTPARMS.

"***** NCP GREATER THAN MAX NCP ..."
See QNCN limits in LSTPARMS.

"***** NIS GREATER THAN MAX NIS ... "
See ZNIS limits in BLADEGEO.

"** NOIZEXEC CALLED WITH KEYWORD ..."
An unrecognizable subcommand was found. The subcommand must be "EXECCASE".

"***** NSM GREATER THAN MAX NSM ... "
See QNSM limits in LSTPARMS.

"***** NSM * NCP GREATER THAN ..."
Ensure that QNSM * QNCP < 1000 in LSTPARMS.

"*** NUMBER OF NODAL DIAMETERS (K) MUST ..."
If QQ = 0 then QK must equal zero in the LSTPARMS input.

"***** NX GREATER THAN ..."
See ZNPCOV limits in BLADEGEO.

"***** THE DATA FOR THIS RUN & THE DATA ..."
A label is attached to the "K-INVERSE" matrix describing the parameters used to create it. The current value of the input variable listed below the error message does not agree with that in the attached label.
Cause : This generally arises because a "K-INVERSE" matrix from a previous run was used as input to this run (see QPART1 in LSTPARMS) and the data used to generate that matrix is different than that being used to run the current case.

"*** THE NO. OF DIRECTIVITY POINTS ..."
See ZNX limits in NOIZPARM.

"*** THE NO. OF HARMONICS IS GREATER ..."
See ZMMAX limits in NOIZPARM.

"*** THE NO. OF HARMONICS IS GREATER THAN ALLOWED 150'
"*** THE NO. OF HARMONICS X THE NO. OF BLADES IS LIMITED TO

1000'

**** THE NO. OF RADIAL INTEGRATION POINTS IS LIMITED TO 2000

**** THE NO. OF DIRECTIVITY POINTS IS LIMITED TO 20'

Cause - input values larger than permissible

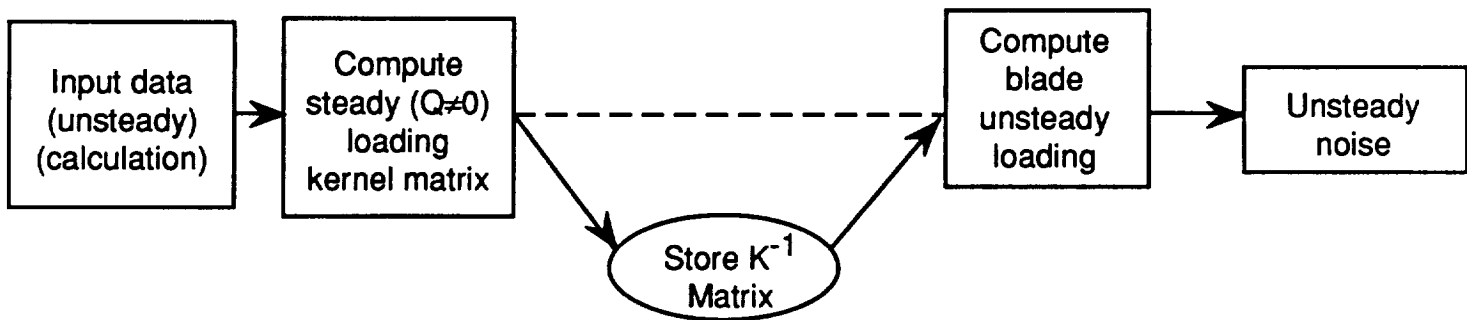
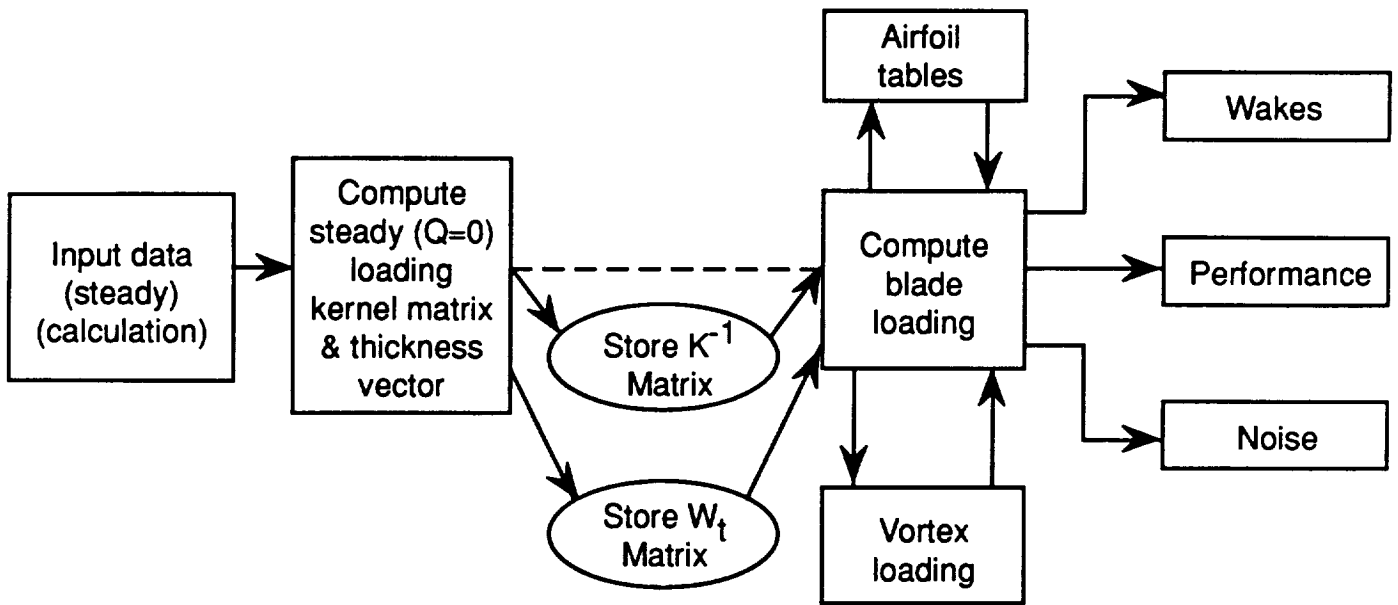
Solution - correct input

" KKR2 VALUE = *computed* LARGER THAN HANKS DIMENSION FOR HARMONIC
number, MMAX IS BEING RESET TO PREVENT ERROR '

Cause : limited storage in Hankel function array and
conservative selection of integration step size.
This error is most likely to occur at high flight
Mach number, forward directivities, and/or high
harmonic order.

Solution :

- 1) Reduce distance forward of plane of rotation.
- 2) See note on selection of ZKXTND in the input
section.
- 3) Reduce ZKMIN and ZOMEGA from the default values
of 10. Values of 6 or 7 can give acceptable
results.



UAAP system overview
Figure 1

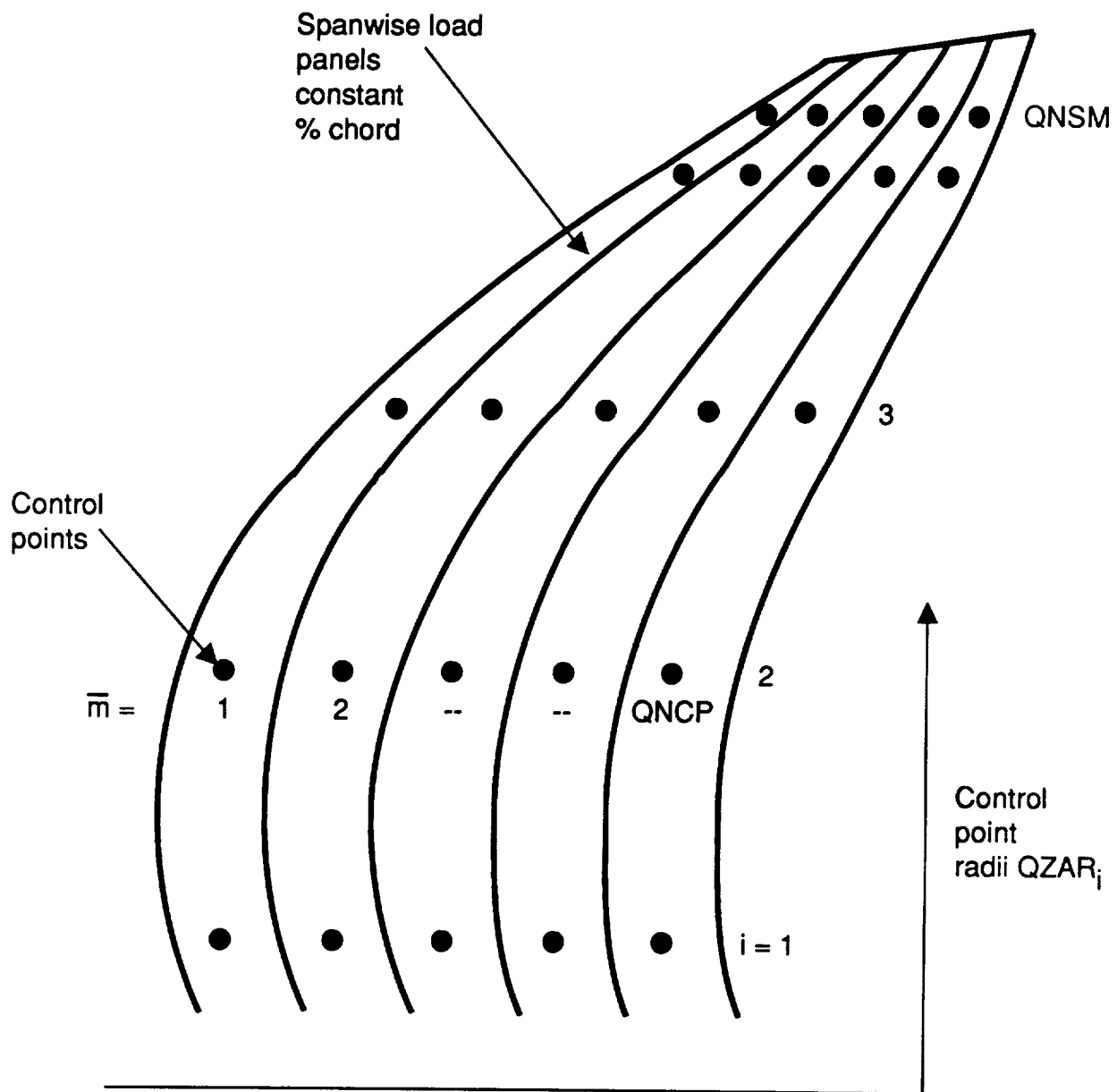


Figure 2 Spanwise load panels and control points

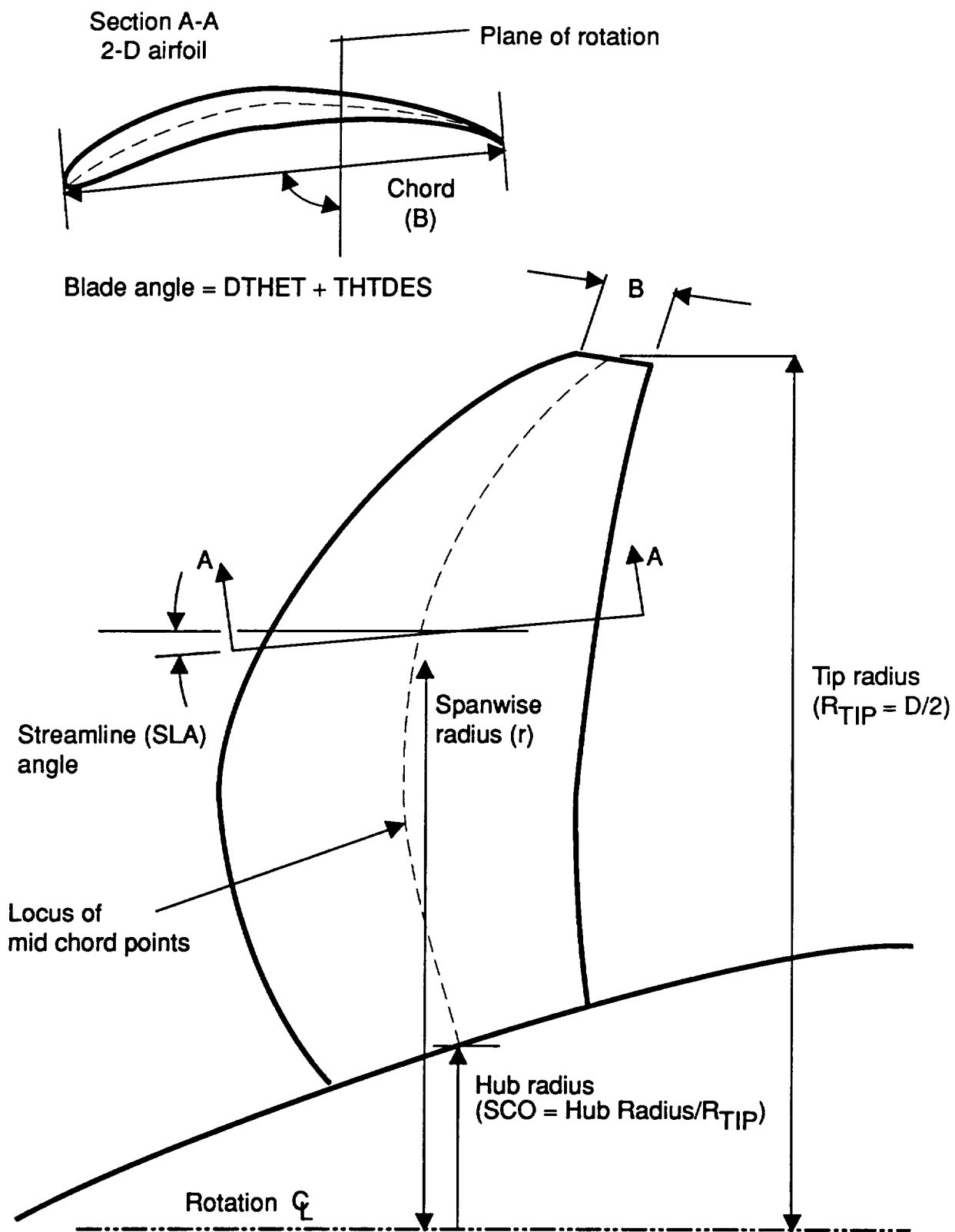


Figure 3 Blade geometry nomenclature (2-D coords)

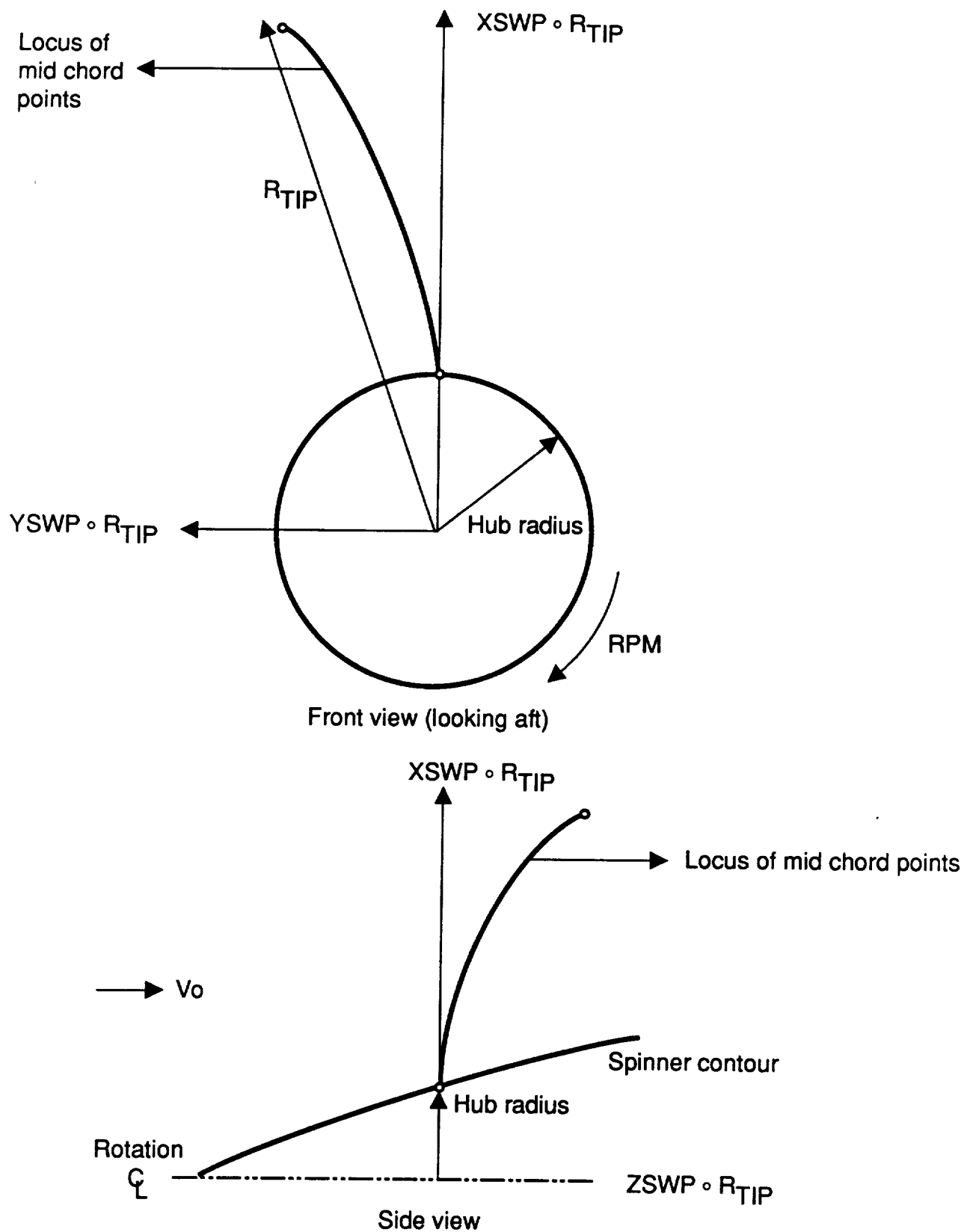


Figure 4 Blade geometry nomenclature (2-D coords)

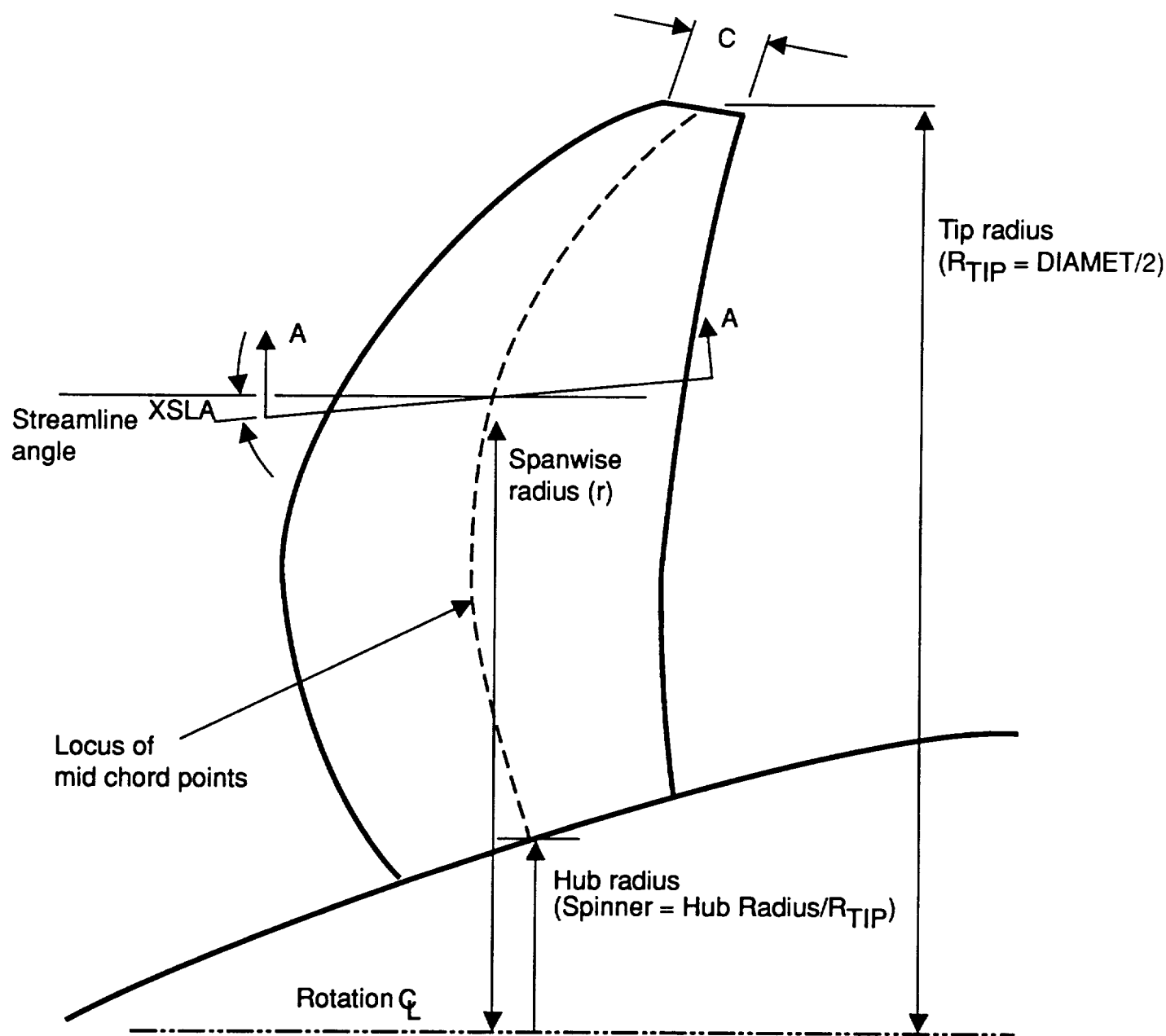


Figure 5 Blade geometry nomenclature (RXY coord)

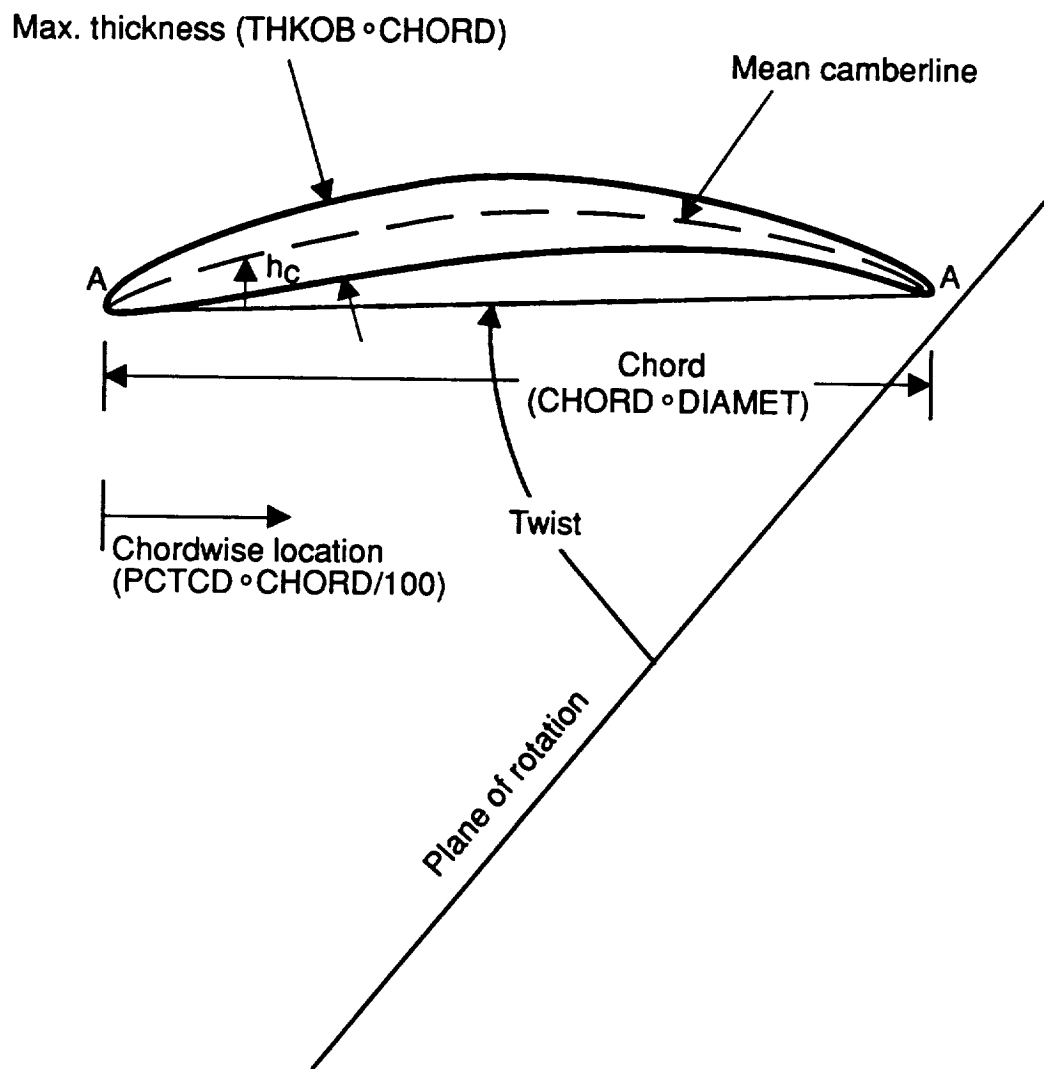


Figure 6 Blade geometry nomenclature (RXY coord)

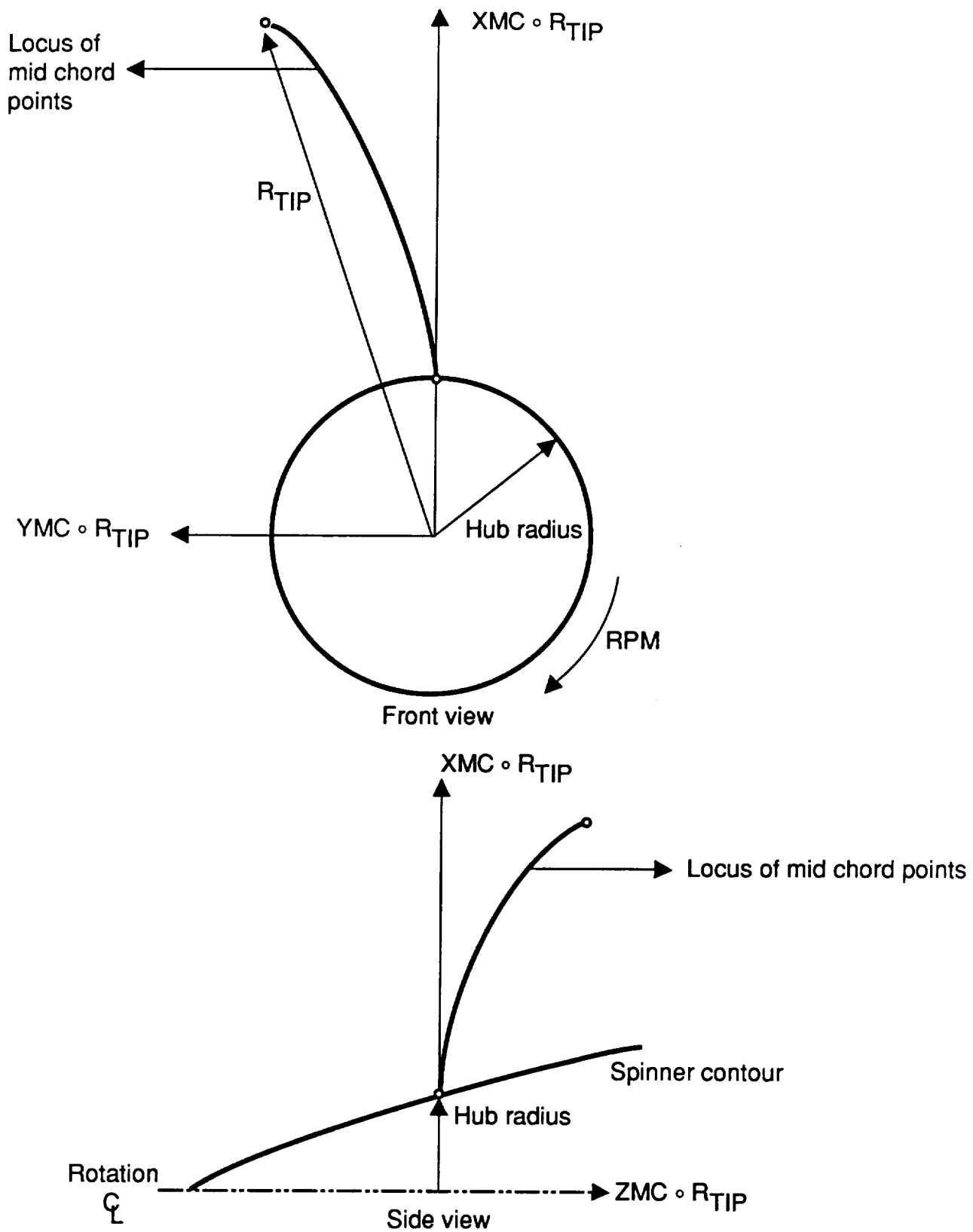


Figure 7 Blade geometry nomenclature (RXY coord)

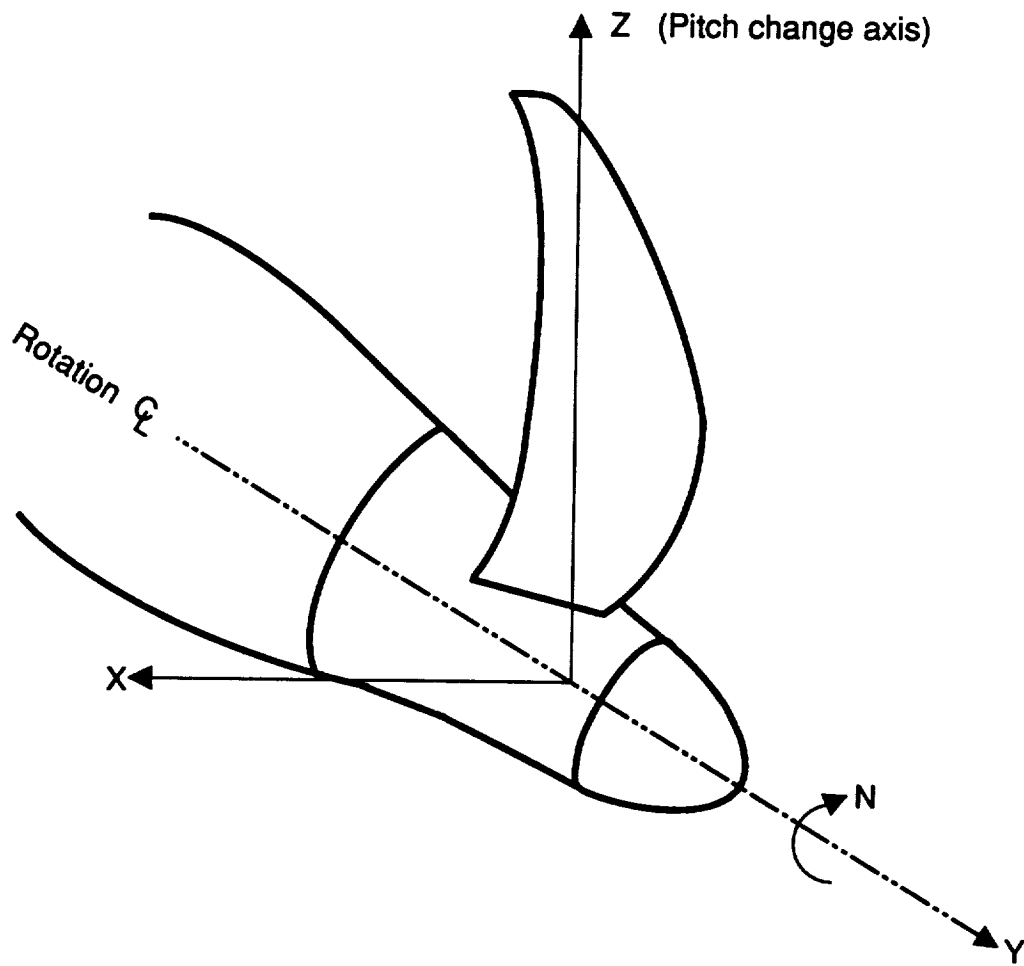


Figure 8 Blade geometry nomenclature (XYZ coords)

READ / PRINT ALL INPUT DATA : INPTMR INPUTRM TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1

 HEADER

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM
 J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
 FAR FIELD NOISE

END

RUNPARMS

L1 1.0 59.0 0.967 3.10 0.70
 L11 0.0 0.0

END

NOIZPARM

L1 2.0 1.4.
 L9 4.1 2.0. -2. -5.
 L61 0.
 L67 1.

END

VORTPARM

L1 1.

END

LSTPARMS

L1 1.0

L5 1024.

C MODOPT

L7 4

L17 0. 0. 0.

C PART1

L20 3.0

C NBOPT = 2 LEADING EDGE SINGULARITY

L28 2

C NON-LINEAR ITERATION NUMBER

L29 5

END

AIRPARMS

L1 1.0 24. 5.

L17 0

END

WAKEPARM

L1 1.0

L6 1

L9 .0001

L10 0

L12 .001

L21 0

L4 1 0

L351 .70 .72 .824

L401 1.0569

L50 1 0 98 .03

L701 .391

END

VELGRADS

VELOCITY GRADIENTS AT MN=.26, J=1.194

-C

L1 1. 1. 14. 20. 251.4 12.25 -3.197

L25 2.360 3.533 5.038 6.622 8.334 10.062 11.797 13.924 16.260

18.572	21.193	24.021	27.135	31.349	230.400	240.990	243.260	245.020
209.230	213.570	222.750	229.580	234.780	-14.000	-14.000	-14.000	-14.000
246.290	247.370	248.230	248.960	249.700	-14.000	-14.000	-14.000	-14.000
4.130	4.800	5.889	7.198	8.723	10.331	11.988	14.054	16.348
18.635	21.239	24.053	27.159	31.366	246.180	246.250	246.560	247.070
248.290	247.220	247.200	246.760	246.360	-12.500	-12.500	-12.500	-12.500
247.620	248.220	248.790	249.350	249.920	-12.500	-12.500	-12.500	-12.500
5.080	5.576	6.466	7.625	9.042	10.579	12.187	14.211	16.472
18.734	21.317	24.115	27.208	31.402	249.110	248.350	248.150	248.330
275.440	268.570	260.640	254.730	250.980	-11.000	-11.000	-11.000	-11.000
248.640	249.030	249.430	249.830	250.280	10.676	12.266	14.275	16.529
-11.000	-11.000	-11.000	-11.000	-11.000	10.786	12.369	14.377	16.631
-11.000	-11.000	-11.000	-11.000	-11.000	250.340	249.420	249.080	249.160
5.350	5.814	6.661	7.781	9.164	-10.250	-10.250	-10.229	-10.118
18.789	21.368	24.159	27.243	31.427	-10.250	-10.250	-10.250	-10.250
275.670	269.810	262.360	256.410	252.420	-9.516	-9.469	-9.266	-8.921
249.420	249.760	250.040	250.290	250.600	10.867	12.438	14.440	16.693
-9.913	-9.684	-9.543	-9.500	-9.500	249.940	249.790	249.830	250.170
5.550	6.007	6.836	7.931	9.291	-8.737	-8.679	-8.441	-7.897
18.890	21.464	24.245	27.315	31.481	11.002	12.559	14.540	16.768
259.980	258.100	255.650	253.370	251.410	258.080	256.560	255.080	253.900
249.930	250.340	250.710	250.990	251.160	-7.843	-7.776	-7.548	-7.062
-9.140	-9.206	-9.326	-9.443	-9.508	11.086	12.634	14.602	16.816
-8.458	-8.010	-7.619	-7.540	-7.540	259.150	257.380	255.610	254.250
5.660	6.123	6.955	8.043	9.388	-6.947	-6.870	-6.658	-6.235
18.947	21.515	24.288	27.349	31.507	11.175	12.718	14.673	16.874
247.760	248.890	249.950	250.280	250.180	258.000	256.800	255.390	254.220
250.530	250.810	251.110	251.330	251.400	-6.049	-5.969	-5.774	-5.403
-8.050	-8.177	-8.342	-8.505	-8.648	11.245	12.779	14.727	16.920
-7.371	-6.781	-6.334	-6.303	-6.294	253.530	253.450	253.210	252.860
5.700	6.211	7.086	8.191	9.534	-5.152	-5.064	-4.886	-4.577
19.004	21.558	24.321	27.373	31.525	-4.930	-4.978	-5.145	-5.178
256.510	259.300	261.400	261.270	259.810	-4.248	-3.849	-3.705	-3.697
253.150	252.510	252.040	251.710	251.550	6.380	6.789	7.550	8.580
-7.270	-7.364	-7.523	-7.665	-7.780				
-6.589	-6.049	-5.674	-5.654	-5.646				
5.760	6.282	7.169	8.280	9.623				
19.042	21.588	24.343	27.391	31.538				
256.270	259.590	262.120	262.310	260.980				
253.430	252.780	252.230	251.850	251.700				
-6.490	-6.560	-6.698	-6.825	-6.915				
-5.811	-5.319	-5.017	-5.005	-4.999				
5.930	6.427	7.289	8.383	9.717				
19.089	21.624	24.372	27.414	31.556				
254.970	257.000	258.720	259.250	258.910				
253.500	252.950	252.400	252.020	251.860				
-5.710	-5.763	-5.890	-5.984	-6.043				
-5.025	-4.578	-4.361	-4.348	-4.344				
6.150	6.602	7.416	8.481	9.798				
19.126	21.653	24.394	27.432	31.570				
255.940	254.960	253.920	253.520	253.500				
252.550	252.420	252.270	252.060	251.970				
-4.930	-4.978	-5.070	-5.145	-5.178				
-4.248	-3.849	-3.705	-3.699	-3.697				
6.380	6.789	7.550	8.580	9.876				

Figure 10 Program Output Listing : Input Echo

[illegible]

Figure 11 **Program Output Listing : Input Echo**

```

BLADEGEO(2-DCOORD)
C **
C ** ROTOR
C **
C ** GEOMETRIC DESCRIPTION
C **
L 1 1.0
L31 5.0 2.0417 .245 .0 .0
L41 .9907 .9495 .8795 .7866 .6792 .5668 .4594 .3665 .2965 .2553
L51 .020 .020 .022 .024 .028 .038 .049 .066 .103 .158
L61 .079 .106 .142 .174 .194 .204 .198 .184 .171 .165
L71 .2070 .2210 .2340 .2300 .2070 .1680 .1320 .0930 .0690 .0500
L81 -7.20 -6.10 -3.80 -1.40 2.700 7.700 13.00 17.70 20.90 23.90
L341 .072 -66.1 .235 0. 2. 57.46 55.46 1. 0.
L381 1.10 1.12 1.15 1.24 1.45 1.85 2.60 3.42 4.30 5.40
L711 .973 .937 .874 .7866 .6792 .5668 .4594 .3665 .2965 .2553
L721 .189 .165 .120 .064 .012 -.018 -.026 -.019 -.010 -.004
L731 .179 .159 .123 .069 .015 -.025 -.042 -.037 -.016 -.006
L741 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
L950 22
L951 .1 .3 .4 .5 .55 .6 .65 .7 .75 .8 .825 .85 .875 .9 .925
.95 .96 .97 .98 .99 .998 1.0
END
AEROEXEC(EXECCASE)
MAKEEXEC(EXECCASE)
NOIZEEXEC(EXECCASE)
ENDCASE
ENDJOB

```

Figure 12 Program Output Listing : Input Echo

```

INPUT PAGE HEADINGS      : HEADER      HEADER      TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1
*****
SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

      BLADE ROM
J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.
EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

```

Figure 13 Program Output Listing : Input Echo

```

RUNPARMS INPUT / OUTPUT      : RUNPRM      RUNPARMS      TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA  1
*****
SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

      BLADE RON
J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

*****
DEBUG (001) 1.0
TEMP.FDEG (002) 59.0
RHO/RHO 0 (003) 0.9670
JF,ADV.RAT. (004) 3.100
MACH NO. (005) 0.700
*****

```

Figure 14 Program Output Listing : Runparms Output

XX

BLADE ROW

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

**EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE**

* * *

[illegible]

Figure 15 **Program Output Listing : Noizparm Output**

```

RUN PARAMETERS FOR VORTEX LIFT CALC.      VORTPARM      TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1
*****
SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

      BLADE ROM
J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

*****
DEBUG (001) 1.0
LE VORTEX LIFT (002) 1.0
SIDE VORT LIFT (003) 1.0
AUG LIFT (004) 1.0
ZEFF AUGLFT (005) 0.9700
O-LIFT:1-RADIAL(006) 0.0

```

Figure 16 Program Output Listing : Vortparm Output

BLADE ROW
J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

Figure 17 **Program Output Listing : Lstparms Output**

AIRFOIL DATA OPTIONS INPUT : AIRPRM AIRPARMS TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM
J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

DEBUG (001) 1.
AIRF.NPB. (002) 24.
AIRF.TYP. (003) 5.
AIR. CL/CD (013) 0.0000
CD MULT. (015) 0.0000
DELTA CD (017) 0.0000

Figure 18 Program Output Listing : Airparms Output

PROPELLER WAKE ANALYSIS INPUT :NAKPRM WAKEPARM TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

DEBUG	(001)	1.0000
K	(002)	0.0500
ADVR	(003)	0.00
NOR	(004)	1.
NPX	(005)	0.
IPLOT	(006)	1.
NPSKN	(008)	1.000000
TOL	(009)	0.000100
MM1	(010)	0.
TOL1	(012)	0.001000
LAST	(013)	20.
Z0	(016)	0.700000
NORM	(017)	0.5000
ADPT	(018)	1.0000
ILFP	(019)	0.
IPRT	(020)	0.
MM2	(021)	0.
C	(022)	0.
IVWK	(023)	0.
IWK	(024)	0.
NCS	(050)	1.
MMU	(051)	0.
MTV	(052)	98.
MM	(053)	98.
FPHM	(054)	0.0300
ROUT	(351)	0.7000
XTBAR	(701)	0.3910

VELOCITY /V	(+25)	256.510	259.300	261.400	261.270	259.810	258.080	256.560	255.080	253.900	253.150
RAD.LOC /R	(025)	252.510	252.040	251.710	251.550	9.623	11.086	12.634	14.602	16.816	19.042
AXL.LOC-Z/R	(+25)	5.760	6.282	7.169	8.280	-6.915	-6.947	-6.870	-6.658	-6.235	-5.811
VELOCITY /V	(+25)	21.588	24.343	27.391	31.538	260.980	259.150	257.380	255.610	254.250	253.430
RAD.LOC /R	(025)	-6.490	-6.560	-6.698	-6.825	9.717	11.175	12.718	14.673	16.874	19.089
AXL.LOC-Z/R	(+25)	-5.319	-5.017	-5.005	-4.999	-6.043	-6.049	-5.969	-5.774	-5.603	-5.025
VELOCITY /V	(+25)	256.270	259.590	262.120	262.310	258.910	258.000	256.800	255.390	254.220	253.500
RAD.LOC /R	(025)	252.780	252.230	251.850	251.700	9.798	11.245	12.779	14.727	16.920	19.126
AXL.LOC-Z/R	(+25)	5.930	6.427	7.289	8.383	-5.178	-5.152	-5.064	-4.886	-4.577	-4.248
VELOCITY /V	(+25)	21.624	24.372	27.414	31.556	253.500	253.530	253.450	253.210	252.860	252.550
RAD.LOC /R	(025)	-5.710	-5.763	-5.890	-5.984	9.876	11.313	12.838	14.778	16.963	19.163
AXL.LOC-Z/R	(+25)	-4.578	-4.361	-4.368	-4.344	-4.307	-4.255	-4.165	-4.005	-3.752	-3.471
VELOCITY /V	(+25)	254.970	257.000	258.720	259.250	247.990	248.110	248.650	249.450	250.240	250.790
RAD.LOC /R	(025)	252.950	252.400	252.020	251.860	9.973	11.397	12.915	14.849	17.030	19.225
AXL.LOC-Z/R	(+25)	6.150	6.602	7.416	8.481	-3.459	-3.418	-3.305	-3.106	-2.718	-2.344
VELOCITY /V	(+25)	21.653	24.394	27.432	31.570	247.570	247.910	248.590	249.500	250.440	251.230
RAD.LOC /R	(025)	-4.930	-4.978	-5.070	-5.145	10.027	11.450	12.969	14.907	17.090	19.282
AXL.LOC-Z/R	(+25)	-3.849	-3.705	-3.699	-3.697	-2.592	-2.650	-2.494	-2.170	-1.669	-1.220
VELOCITY /V	(+25)	255.940	254.960	253.920	253.520	244.870	246.760	248.220	249.670	250.890	251.740
RAD.LOC /R	(025)	252.420	252.270	252.060	251.970	10.152	11.563	13.069	14.990	17.155	19.333
AXL.LOC-Z/R	(+25)	6.380	6.789	7.550	8.580	-1.745	-1.784	-1.637	-1.344	-0.890	-0.485
VELOCITY /V	(+25)	21.682	24.417	27.452	31.587	255.380	255.520	255.410	255.180	254.890	254.540
RAD.LOC /R	(025)	-4.150	-4.185	-4.251	-4.299	10.249	11.649	13.142	15.049	17.202	19.371
AXL.LOC-Z/R	(+25)	-3.119	-3.050	-3.050	-3.050	-0.898	-0.917	-0.783	-0.523	-0.124	0.246
VELOCITY /V	(+25)	250.510	249.440	248.320	247.690	257.710	257.080	256.510	255.970	255.560	255.150
RAD.LOC /R	(025)	251.870	252.300	252.500	252.440	10.342	11.734	13.219	15.114	17.255	19.413
AXL.LOC-Z/R	(+25)	6.490	6.922	7.703	8.738	-0.047	-0.041	0.072	0.293	0.654	0.989
VELOCITY /V	(+25)	21.789	24.510	27.530	31.648	255.590	255.770	255.920	256.010	255.880	255.560
RAD.LOC /R	(025)	-2.030	-2.157	-2.358	-2.484	10.450	11.829	13.301	15.181	17.306	19.450
AXL.LOC-Z/R	(+25)	-0.792	-0.460	-0.453	-0.443	0.800	0.826	0.927	1.115	1.420	1.721
VELOCITY /V	(+25)	231.000	234.410	238.870	242.240	247.570	247.910	248.590	249.500	250.440	251.230
RAD.LOC /R	(025)	252.300	252.650	252.780	252.630	10.027	11.450	12.969	14.907	17.090	19.282
AXL.LOC-Z/R	(+25)	6.620	7.063	7.850	8.877	-2.592	-2.650	-2.494	-2.170	-1.669	-1.220
VELOCITY /V	(+25)	21.827	24.538	27.549	31.662	244.870	246.760	248.220	249.670	250.890	251.740
RAD.LOC /R	(025)	-1.260	-1.372	-1.551	-1.659	10.152	11.563	13.069	14.990	17.155	19.333
AXL.LOC-Z/R	(+25)	-0.093	0.180	0.186	0.194	-1.745	-1.784	-1.637	-1.344	-0.890	-0.485
VELOCITY /V	(+25)	249.000	251.240	253.540	254.780	255.380	255.520	255.410	255.180	254.890	254.540
RAD.LOC /R	(025)	254.060	253.540	253.120	252.770	10.249	11.649	13.142	15.049	17.202	19.371
AXL.LOC-Z/R	(+25)	6.760	7.196	7.971	8.986	-0.898	-0.917	-0.783	-0.523	-0.124	0.246
VELOCITY /V	(+25)	21.857	24.561	27.568	31.676	257.710	257.080	256.510	255.970	255.560	255.150
RAD.LOC /R	(025)	-0.490	-0.585	-0.738	-0.830	10.342	11.734	13.219	15.114	17.255	19.413
AXL.LOC-Z/R	(+25)	0.604	0.820	0.825	0.831	-0.047	-0.041	0.072	0.293	0.654	0.989
VELOCITY /V	(+25)	260.060	259.830	259.180	258.430	255.590	255.770	255.920	256.010	255.880	255.560
RAD.LOC /R	(025)	254.560	253.830	253.240	252.860	10.450	11.829	13.301	15.181	17.306	19.450
AXL.LOC-Z/R	(+25)	6.890	7.317	8.081	9.087	0.800	0.826	0.927	1.115	1.420	1.721
VELOCITY /V	(+25)	21.888	24.584	27.585	31.689	255.590	255.770	255.920	256.010	255.880	255.560
RAD.LOC /R	(025)	0.280	0.201	0.067	-0.006	10.450	11.829	13.301	15.181	17.306	19.450
AXL.LOC-Z/R	(+25)	1.292	1.470	1.472	1.476	0.800	0.826	0.927	1.115	1.420	1.721
VELOCITY /V	(+25)	255.960	255.840	255.650	255.540	255.590	255.770	255.920	256.010	255.880	255.560
RAD.LOC /R	(025)	254.910	254.090	253.430	253.000	10.450	11.829	13.301	15.181	17.306	19.450
AXL.LOC-Z/R	(+25)	7.030	7.450	8.207	9.205	0.800	0.826	0.927	1.115	1.420	1.721
VELOCITY /V	(+25)	21.915	24.604	27.602	31.703	255.590	255.770	255.920	256.010	255.880	255.560
RAD.LOC /R	(025)	1.050	0.987	0.876	0.821	10.450	11.829	13.301	15.181	17.306	19.450
AXL.LOC-Z/R	(+25)	1.989	2.110	2.111	2.113	0.800	0.826	0.927	1.115	1.420	1.721

Figure 20B Program Output Listing : Velgrads Output (continued)

VELOCITY /V	(+25)	237.910	240.570	244.320	247.690	250.520	252.580	253.950	254.850	255.080	254.930
RAD.LOC /R	(025)	254.540	253.990	253.490	253.100	10.537	11.911	13.372	15.238	17.349	19.483
AXL.LOC-Z/R	(+25)	7.160	7.563	8.304	9.295	1.647	1.693	1.781	1.938	2.195	2.454
VELOCITY /V	(+25)	21.938	24.622	27.617	31.715	1.649	1.693	1.781	1.938	2.195	2.454
RAD.LOC /R	(025)	1.820	1.773	1.688	1.649	243.990	247.460	249.850	251.690	252.790	253.300
AXL.LOC-Z/R	(+25)	2.686	2.750	2.750	2.750	10.864	12.155	13.551	15.358	17.426	19.533
VELOCITY /V	(+25)	224.980	228.480	233.830	239.220	243.990	247.460	249.850	251.690	252.790	253.300
RAD.LOC /R	(025)	253.610	253.690	253.540	253.210	10.864	12.155	13.551	15.358	17.426	19.533
AXL.LOC-Z/R	(+25)	7.800	8.156	8.819	9.718	3.053	3.072	3.093	3.154	3.266	3.377
VELOCITY /V	(+25)	21.970	24.645	27.636	31.731	255.740	255.650	255.380	255.050	254.730	254.420
RAD.LOC /R	(025)	3.000	3.006	3.019	3.035	11.099	12.327	13.677	15.444	17.482	19.570
AXL.LOC-Z/R	(+25)	3.469	3.500	3.500	3.500	4.250	4.250	4.250	4.250	4.250	4.250
VELOCITY /V	(+25)	253.070	253.740	254.730	255.440	264.870	261.610	259.210	257.230	255.870	255.040
RAD.LOC /R	(025)	254.130	253.920	253.660	253.300	264.870	261.610	259.210	257.230	255.870	255.040
AXL.LOC-Z/R	(+25)	8.350	8.650	9.226	10.035	4.250	4.250	4.250	4.250	4.250	4.250
VELOCITY /V	(+25)	21.996	24.665	27.652	31.743	264.870	261.610	259.210	257.230	255.870	255.040
		4.250	4.250	4.250	4.250	264.870	261.610	259.210	257.230	255.870	255.040
		4.250	4.250	4.250	4.250	264.870	261.610	259.210	257.230	255.870	255.040
		280.180	277.580	273.460	269.040	264.870	261.610	259.210	257.230	255.870	255.040
		254.450	254.040	253.750	253.410	264.870	261.610	259.210	257.230	255.870	255.040

Figure 20C Program Output Listing : Velgrads Output (continued)

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

LST PROGRAM AND VERSION F271M1 08/10/87

TEMP, DEGF. 59.0

RHO/RHO STD 0.9670

SPEED OF SOUND 1116.4

ADVANCE RATIO 3.1000

FLIGHT MACH NO. 0.7000

FLIGHT SPD FPS 463.0348

TIP ROT. MACH 0.7094

TIP SPD. FPS 791.9785

RPM 7408.3719

TIP HEL. MACH 0.9966

START BLENDING 0.9000

DIAMETER 2.0417

NO. BLADES 5

NO. INPT. STA. 22

FREQ. OF UNST. 0.0

NO. NODAL DIA. 0

K-DOWN 0.0250

K-START 0.0100

INPUT STATIONS 0.1000

B/D 0.8250

0.9980

0.1747

0.1604

0.0737

0.0723

76.0697

53.1485

48.1305

0.0177

0.0624

0.1326

-0.0038

-0.0060

-0.0081

0.2149

0.0231

0.0200

0.0324

0.2339

0.2042

-9.6752

38.3975

31.3386

0.3000 0.4000 0.5000 0.5500 0.6000 0.6500 0.7000 0.7500 0.8000

0.8500 0.8750 0.9000 0.9250 0.9500 0.9600 0.9700 0.9800 0.9900

1.0000 0.1747 0.1901 0.2005 0.2023 0.2007 0.1885 0.1797 0.1678

0.1517 0.1419 0.1309 0.1186 0.1048 0.0987 0.0925 0.0859 0.0792

0.1604 0.1517 0.1419 0.1309 0.1186 0.1048 0.0987 0.0925 0.0859

0.0737 0.0723 71.5341 66.5131 64.0872 61.7739 59.5659 57.4282 55.4315

0.0723 76.0697 52.5552 51.9334 51.1900 50.3317 49.4628 48.8484 48.3235

48.1305 0.0177 -0.0096 -0.0176 -0.0096 0.0016 0.0158 0.0328 0.0521

0.0624 0.0730 0.0730 0.0624 0.0500 0.0400 0.0300 0.0200 0.0100

0.1326 0.1334 0.0029 -0.0064 -0.0069 -0.0076 -0.0083 -0.0086 -0.0088

-0.0038 -0.0060 -0.0081 -0.0081 -0.0081 -0.0081 -0.0081 -0.0081 -0.0081

0.2149 0.0231 0.0226 0.0214 0.0205 0.0200 0.0199 0.0200 0.0200

0.0200 0.0200 0.0200 0.0200 0.0200 0.0200 0.0200 0.0200 0.0200

0.0324 0.0324 0.0324 0.0324 0.0324 0.0324 0.0324 0.0324 0.0324

0.2339 0.2339 0.2339 0.2339 0.2339 0.2339 0.2339 0.2339 0.2339

0.2042 0.2042 0.2042 0.2042 0.2042 0.2042 0.2042 0.2042 0.2042

-9.6752 -9.6752 -9.6752 -9.6752 -9.6752 -9.6752 -9.6752 -9.6752 -9.6752

38.3975 38.3975 38.3975 38.3975 38.3975 38.3975 38.3975 38.3975 38.3975

31.3386 31.3386 31.3386 31.3386 31.3386 31.3386 31.3386 31.3386 31.3386

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31.3386 31.3386 31.3386 31.3386 31.3386 31.3386 31.3386 31.3386 31.3386

Figure 22A Program Output Listing : Aeroexec Output

LST CAMBER TABLE :F271 AEROEXEC EXCEC CASE TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

CAMBER SURFACE AS A FUNCTION OF SMALL R/R AND PERCENT CHORD - UNBAR TABLE FORMAT

TABLE NO. 1. DEGREE 1.

CAMBER SURFACE AS A FUNCTION OF SMALL R/R AND PERCENT CHORD - UNBAR TABLE FORMAT									
0.00000E+00	5.00000E-02	1.00000E-01	1.50000E-01	2.00000E-01	2.50000E-01	3.00000E-01	3.50000E-01	4.00000E-01	4.50000E-01
1.000E-01	0.00000E+00	2.25095E-03	3.73188E-03	5.02866E-03	6.11935E-03	7.04656E-03	7.81158E-03	8.42306E-03	8.88568E-03
3.000E-01	0.00000E+00	2.25095E-03	3.73188E-03	5.02866E-03	6.11935E-03	7.04656E-03	7.81158E-03	8.42306E-03	8.88568E-03
4.000E-01	0.00000E+00	2.46402E-03	4.31100E-03	5.76854E-03	6.96482E-03	7.95588E-03	8.74963E-03	9.36129E-03	9.80118E-03
5.000E-01	0.00000E+00	3.03214E-03	4.97417E-03	6.60032E-03	7.92610E-03	9.01808E-03	9.88932E-03	1.05604E-02	1.10448E-02
5.500E-01	0.00000E+00	3.16316E-03	5.23222E-03	6.92168E-03	8.29189E-03	9.41677E-03	1.03112E-02	1.09985E-02	1.14937E-02
6.000E-01	0.00000E+00	3.33780E-03	5.55405E-03	7.32677E-03	8.75976E-03	9.93219E-03	1.08613E-02	1.15730E-02	1.20841E-02
6.500E-01	0.00000E+00	3.58339E-03	5.94166E-03	7.82279E-03	9.33833E-03	1.05756E-02	1.15533E-02	1.23004E-02	1.28358E-02
7.000E-01	0.00000E+00	3.81659E-03	6.27428E-03	8.24626E-03	9.83045E-03	1.12145E-02	1.21398E-02	1.29171E-02	1.34737E-02
7.500E-01	0.00000E+00	4.03908E-03	6.45629E-03	8.46821E-03	1.00792E-02	1.13888E-02	1.24192E-02	1.32040E-02	1.37651E-02
8.000E-01	0.00000E+00	4.25912E-03	6.53904E-03	8.55884E-03	1.01698E-02	1.14741E-02	1.24953E-02	1.32689E-02	1.38176E-02
8.250E-01	0.00000E+00	4.40404E-03	6.56353E-03	8.58411E-03	1.01931E-02	1.14933E-02	1.25086E-02	1.32757E-02	1.38168E-02
8.500E-01	0.00000E+00	4.01404E-03	6.56849E-03	8.58678E-03	1.01930E-02	1.14903E-02	1.25024E-02	1.32663E-02	1.38046E-02
8.750E-01	0.00000E+00	4.00755E-03	6.55089E-03	8.56422E-03	1.01684E-02	1.14651E-02	1.24786E-02	1.32459E-02	1.37890E-02
9.000E-01	0.00000E+00	3.96038E-03	6.49891E-03	8.50042E-03	1.00989E-02	1.13943E-02	1.24108E-02	1.31840E-02	1.37362E-02
9.250E-01	0.00000E+00	3.73932E-03	6.12265E-03	7.99636E-03	9.87864E-03	1.11450E-02	1.21394E-02	1.28969E-02	1.34383E-02
9.500E-01	0.00000E+00	3.67605E-03	6.00312E-03	7.83475E-03	9.29257E-03	1.06953E-02	1.16379E-02	1.23517E-02	1.28579E-02
9.700E-01	0.00000E+00	3.60236E-03	5.89111E-03	7.67111E-03	9.09441E-03	1.02411E-02	1.11344E-02	1.18088E-02	1.22845E-02
9.800E-01	0.00000E+00	3.51270E-03	5.75924E-03	7.50779E-03	8.89843E-03	1.00182E-02	1.08998E-02	1.15485E-02	1.20127E-02
9.900E-01	0.00000E+00	3.45168E-03	5.63973E-03	7.34941E-03	8.70807E-03	9.80252E-03	1.06545E-02	1.12980E-02	1.17520E-02
9.980E-01	0.00000E+00	3.41278E-03	5.54915E-03	7.23087E-03	8.56587E-03	9.64086E-03	1.04776E-02	1.11097E-02	1.15554E-02
1.000E+00	0.00000E+00	3.37437E-03	5.52828E-03	7.20227E-03	8.53217E-03	9.60263E-03	1.04359E-02	1.10654E-02	1.15093E-02
4.50000E-01 5.00000E-01 5.50000E-01 6.00000E-01 6.50000E-01 7.00000E-01 7.50000E-01 8.00000E-01 8.50000E-01 9.00000E-01									
1.000E-01	9.19677E-03	9.35643E-03	9.36102E-03	9.20660E-03	8.88472E-03	8.38824E-03	7.70172E-03	6.80105E-03	5.66521E-03
3.000E-01	9.19677E-03	9.35643E-03	9.36102E-03	9.20660E-03	8.88472E-03	8.38824E-03	7.70172E-03	6.80105E-03	5.66521E-03
4.000E-01	1.00681E-02	1.01665E-02	1.00954E-02	9.85436E-03	9.43692E-03	8.84170E-03	8.05720E-03	7.06448E-03	5.85242E-03
5.000E-01	1.13409E-02	1.14546E-02	1.13847E-02	1.11298E-02	1.06813E-02	1.00376E-02	9.18285E-03	8.09301E-03	6.75180E-03
5.500E-01	1.17952E-02	1.19099E-02	1.18376E-02	1.15743E-02	1.1133E-02	1.04523E-02	9.57367E-03	8.45125E-03	7.06729E-03
6.000E-01	1.23933E-02	1.25087E-02	1.24289E-02	1.21533E-02	1.16715E-02	1.09826E-02	1.00672E-02	8.89703E-03	7.45289E-03
6.500E-01	1.31580E-02	1.32763E-02	1.31895E-02	1.28969E-02	1.23874E-02	1.16603E-02	1.06946E-02	9.45929E-03	7.93387E-03
7.000E-01	1.38087E-02	1.39318E-02	1.38420E-02	1.35382E-02	1.30087E-02	1.25219E-02	1.15034E-02	1.01967E-02	8.57785E-03
7.500E-01	1.41015E-02	1.42238E-02	1.41475E-02	1.38298E-02	1.32868E-02	1.25182E-02	1.14997E-02	1.01966E-02	8.58513E-03
8.000E-01	1.41411E-02	1.42512E-02	1.41737E-02	1.38298E-02	1.32868E-02	1.25182E-02	1.14997E-02	1.01966E-02	8.58513E-03
8.250E-01	1.41321E-02	1.42342E-02	1.41231E-02	1.37987E-02	1.32502E-02	1.24781E-02	1.14585E-02	1.01574E-02	8.55234E-03
8.500E-01	1.41175E-02	1.42176E-02	1.41043E-02	1.37788E-02	1.32295E-02	1.24575E-02	1.14386E-02	1.01398E-02	8.53746E-03
8.750E-01	1.41074E-02	1.42140E-02	1.41078E-02	1.37887E-02	1.32461E-02	1.24794E-02	1.14637E-02	1.01657E-02	8.56156E-03
9.000E-01	1.40660E-02	1.41857E-02	1.40941E-02	1.37894E-02	1.32606E-02	1.25053E-02	1.14978E-02	1.02035E-02	8.59715E-03
9.250E-01	1.37836E-02	1.38837E-02	1.37980E-02	1.35043E-02	1.29915E-02	1.22567E-02	1.12743E-02	1.00099E-02	8.43762E-03
9.500E-01	1.31560E-02	1.32582E-02	1.31637E-02	1.28713E-02	1.23719E-02	1.16635E-02	1.07222E-02	9.51632E-03	8.02127E-03
9.600E-01	1.28534E-02	1.29478E-02	1.28507E-02	1.25605E-02	1.20689E-02	1.13746E-02	1.04539E-02	9.27703E-03	7.82045E-03
9.700E-01	1.25616E-02	1.26513E-02	1.25540E-02	1.22685E-02	1.17868E-02	1.11080E-02	1.02085E-02	9.05954E-03	7.63716E-03

9.800E-01 1.22828E-02 1.23710E-02 1.22759E-02 1.19976E-02 1.15279E-02 1.08652E-02 9.98684E-03 8.86481E-03 7.47427E-03
 9.900E-01 1.20169E-02 1.21041E-02 1.20124E-02 1.17424E-02 1.12847E-02 1.06382E-02 9.78078E-03 8.68394E-03 7.32476E-03
 9.980E-01 1.18154E-02 1.19012E-02 1.18113E-02 1.15462E-02 1.10964E-02 1.04622E-02 9.61987E-03 8.54249E-03 7.20628E-03
 1.000E+00 1.17680E-02 1.18534E-02 1.17639E-02 1.14995E-02 1.10514E-02 1.04199E-02 9.58110E-03 8.50828E-03 7.17784E-03
 9.00000E-01 9.50000E-01 1.00000E+00
 1.000E-01 4.23354E-03 2.48179E-03 1.08630E-06
 3.000E-01 4.23354E-03 2.48179E-03 1.08630E-06
 4.000E-01 4.36498E-03 2.59080E-03 1.13887E-06
 5.000E-01 5.08962E-03 3.01721E-03 1.06776E-06
 5.500E-01 5.34471E-03 3.19663E-03 1.11833E-06
 6.000E-01 5.64976E-03 3.42000E-03 1.00924E-06
 6.500E-01 6.02534E-03 3.65004E-03 1.00959E-06
 7.000E-01 6.36400E-03 3.85014E-03 1.09638E-06
 7.500E-01 6.54026E-03 3.98390E-03 1.08333E-06
 8.000E-01 6.55536E-03 3.98898E-03 1.11614E-06
 8.250E-01 6.53181E-03 3.96829E-03 1.18333E-06
 8.500E-01 6.52144E-03 3.98275E-03 9.46104E-07
 8.750E-01 6.53986E-03 3.99861E-03 1.04599E-06
 9.000E-01 6.56675E-03 4.01285E-03 1.05955E-06
 9.250E-01 6.44745E-03 3.96369E-03 1.06688E-06
 9.500E-01 6.13307E-03 3.80530E-03 9.05758E-07
 9.600E-01 5.97978E-03 3.68485E-03 1.01017E-06
 9.700E-01 5.84273E-03 3.63580E-03 1.02613E-06
 9.800E-01 5.72150E-03 3.59647E-03 1.01898E-06
 9.900E-01 5.60833E-03 3.50676E-03 1.01328E-06
 9.980E-01 5.51940E-03 3.46846E-03 9.89873E-07
 1.000E+00 5.49610E-03 3.42119E-03 1.00885E-06

K(MU,NU) INVERSE MATRIX HAS BEEN READ IN

COEFFICIENT OF SOUND POWER = 0.001031 - SOUND POWER/ (RHO* RPS**3* DIAM**5)

Figure 22C Program Output Listing : Aeroexec Output (continued)

```

SUMMARY OF PERFORMANCE PARH.  :LSTALS  AEROEXEC  EXECCASE  TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1
*****
SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

      BLADE ROM
J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

*****
ITERATION #
CP FRONT      0.1964
CT FRONT      0.0547
ETA FRONT     0.8631

MT VECTOR      HAS BEEN READ IN

*****

COEFFICIENT OF SOUND POWER = 0.001054 - SOUND POWER/ (RHO* RPS**3* DIAM**5)

*****

```

Figure 23 Program Output Listing : Aeroexec Output-Performance

SUMMARY OF NON-LINEAR PERFORM. :LSTALS AEROEXEC EXECCASE TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

ITERATION #

3.

CP FRONT

0.2025

CT FRONT

0.0565

ETA FRONT

0.8653

Figure 24 Program Output Listing : Aeroexec Output-Performance

UAP2 OUTPUT RUN ON: MM/DD/YY AT: HH:MM:SS VERSION: 1

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

RUNNING SRP CASE READ FORMAT = 6 VORTEX LOAD CALC. VERSION 1 USING TIP FORMAT = 0

**** OPERATING CONDITIONS ****

FLIGHT TIP ROT. ADVANCE TEMP., DENSITY
MACH # MACH # RATIO DEG F RATIO

0.7000 0.70% 3.1000 59.00 0.9670

# RADIAL STATIONS	# CHORDWISE STATIONS	# SPANWISE MODES	MODOPT	NBOPT
22	10	8	4	2

BLADE GEOMETRY : THETA 3/4 * BLADES DIAMETER SPINNER CUTOFF
0.00 5.0 2.042 0.2450

RADIAL STATION	CHORD/ DIAM	THICK/ CHORD	MID-CHORD X	MID-CHORD Y	COORDINATES Z	FACE ALINE	MID-CHORD ALINE	SNEEP	L. E. SNEEP	ALPHA 2-D	ALPHA 3-D	L. E. CAMBER	L. E. A.O.A.	ADVANCE ANGLE	TWIST ANGLE
0.1000	0.1747	0.2149	0.2207	-0.0008	0.0028	-0.0038	0.0177	-9.68	-15.24	0.22	-8.14	2.14	-10.28	84.21	76.07
0.3000	0.1747	0.0995	0.2998	-0.0111	-0.0166	0.0029	-0.0096	-10.61	-18.07	1.04	2.98	2.14	0.84	73.09	76.07
0.4000	0.1901	0.0569	0.3993	-0.0240	-0.0411	0.0034	-0.0236	-0.34	-14.51	0.46	3.60	2.47	1.13	67.93	71.53
0.5000	0.2005	0.0441	0.4993	-0.0266	-0.0371	0.0035	-0.0225	13.13	-0.11	0.20	3.38	2.85	0.54	63.13	66.51
0.5500	0.2023	0.0395	0.5496	-0.0215	-0.0283	0.0025	-0.0176	19.08	14.47	0.16	3.22	3.00	0.23	60.87	64.09
0.6000	0.2007	0.0348	0.5999	-0.0122	-0.0150	0.0013	-0.0096	24.66	24.30	0.12	3.08	3.18	-0.10	58.70	61.77
0.6500	0.1956	0.0301	0.6500	0.0019	0.0027	-0.0001	0.0016	29.39	32.17	0.10	2.94	3.40	-0.46	56.63	59.57
0.7000	0.1885	0.0269	0.6997	0.0213	0.0236	-0.0018	0.0158	33.36	38.04	0.14	2.78	3.59	-0.81	54.65	57.43
0.7500	0.1797	0.0250	0.7486	0.0458	0.0744	-0.0039	0.0328	36.34	43.00	0.23	2.67	3.69	-1.03	52.76	55.43
0.8000	0.1678	0.0236	0.7966	0.0741	0.0740	-0.0055	0.0521	38.21	46.37	0.36	2.83	3.74	-0.92	50.97	53.79
0.8250	0.1604	0.0231	0.8202	0.0820	0.0891	-0.0060	0.0624	38.40	49.20	0.41	3.05	3.76	-0.71	50.10	53.15
0.8500	0.1517	0.0226	0.8435	0.1047	0.1023	-0.0064	0.0730	38.17	50.59	0.45	3.30	3.76	-0.46	49.26	52.56
0.8750	0.1419	0.0221	0.8666	0.1209	0.1160	-0.0069	0.0836	37.34	51.60	0.44	3.50	3.75	-0.25	48.44	51.93
0.9000	0.1309	0.0214	0.8894	0.1375	0.1289	-0.0076	0.0941	36.18	52.38	0.40	3.56	3.72	-0.16	47.63	51.19
0.9250	0.1186	0.0205	0.9121	0.1541	0.1411	-0.0083	0.1044	34.82	53.13	0.33	3.48	3.64	-0.16	46.85	50.33
0.9500	0.1048	0.0200	0.9346	0.1702	0.1529	-0.0086	0.1144	33.26	53.66	0.17	3.38	3.50	-0.13	46.09	49.46
0.9600	0.0987	0.0199	0.9437	0.1763	0.1576	-0.0087	0.1183	32.69	54.21	0.03	3.36	3.44	-0.08	45.79	49.14
0.9700	0.0925	0.0199	0.9527	0.1823	0.1622	-0.0086	0.1221	32.19	54.50	-0.11	3.36	3.37	-0.01	45.49	48.85
0.9800	0.0859	0.0200	0.9618	0.1882	0.1669	-0.0085	0.1259	31.80	54.76	-0.36	3.38	3.30	0.08	45.20	48.58
0.9900	0.0792	0.0200	0.9708	0.1940	0.1714	-0.0081	0.1297	31.51	54.95	-0.72	3.42	3.23	0.19	44.91	48.32
0.9980	0.0737	0.0200	0.9780	0.1986	0.1751	-0.0083	0.1326	31.34	55.07	-1.30	3.45	3.18	0.28	44.68	48.13
1.0000	0.0723	0.0200	0.9798	0.1998	0.1760	-0.0081	0.1334	31.30	55.12	-1.83	3.46	3.16	0.30	44.62	48.08

COEFFICIENTS FROM POTENTIAL CALC.:

RADIAL STATION	* CDLST	* CDMIN	* CD0	* CDCLVD	* CDUAP2	LIFT CLLST	L. E. K, MAG.	L. E. THRUST	RELATIVE MACH #	DESIGN CL
0.1000	0.0058	0.0057	0.0057	0.0381	0.0079	0.0558	-0.0218	0.0000	0.7036	0.0324
0.3000	0.0069	0.0058	0.0058	0.0288	0.0105	0.1229	0.0092	0.0000	0.7316	0.0704
0.4000	0.0069	0.0056	0.0056	0.0308	0.0117	0.1574	0.0215	0.0000	0.7553	0.1068
0.5000	0.0064	0.0047	0.0047	0.0298	0.0115	0.1739	0.0112	0.0000	0.7847	0.1463
0.5500	0.0055	0.0044	0.0044	0.0290	0.0107	0.1805	0.0061	0.0000	0.8014	0.1624
0.6000	0.0045	0.0041	0.0041	0.0281	0.0098	0.1883	0.0027	0.0000	0.8192	0.1799
0.6500	0.0038	0.0038	0.0039	0.0273	0.0092	0.1978	0.0008	0.0000	0.8382	0.1979
0.7000	0.0035	0.0034	0.0034	0.0263	0.0090	0.2083	0.0008	0.0000	0.8582	0.2126
0.7500	0.0033	0.0032	0.0032	0.0254	0.0089	0.2201	0.0042	0.0000	0.8792	0.2242
0.8000	0.0032	0.0031	0.0031	0.0244	0.0090	0.2352	0.0145	0.0001	0.9011	0.2316
0.8250	0.0032	0.0031	0.0031	0.0238	0.0090	0.2445	0.0237	0.0002	0.9124	0.2339
0.8500	0.0030	0.0029	0.0029	0.0230	0.0089	0.2543	0.0361	0.0005	0.9239	0.2350
0.8750	0.0027	0.0018	0.0018	0.0219	0.0084	0.2634	0.0518	0.0011	0.9356	0.2344
0.9000	0.0020	-0.0006	-0.0006	0.0203	0.0075	0.2695	0.0701	0.0019	0.9474	0.2316
0.9250	0.0013	-0.0061	-0.0061	0.0182	0.0062	0.2703	0.0888	0.0031	0.9595	0.2271
0.9500	0.0024	-0.0058	-0.0058	0.0153	0.0064	0.2609	0.1033	0.0042	0.9717	0.2209
0.9600	0.0034	-0.0043	-0.0043	0.0138	0.0069	0.2510	0.1058	0.0044	0.9766	0.2178
0.9700	0.0038	-0.0022	-0.0022	0.0119	0.0066	0.2328	0.1045	0.0043	0.9816	0.2145
0.9800	0.0043	-0.0004	-0.0004	0.0096	0.0062	0.2033	0.0970	0.0037	0.9866	0.2110
0.9900	0.0049	0.0012	0.0012	0.0067	0.0059	0.1535	0.0776	0.0024	0.9916	0.2073
0.9980	0.0058	0.0022	0.0022	0.0029	0.0061	0.0723	0.0382	0.0006	0.9956	0.2042
1.0000	0.0073	0.0024	0.0024	0.0006	0.0073	0.0000	0.0000	0.0000	0.9966	0.2034

Figure 25B Program Output Listing : Vortexec Output (continued)

PERFORMANCE CALCULATIONS - LIFT COEFFICIENTS
 **** NOTE THAT VORTEX LIFT COMPONENTS ARE NOT PRESENTED AS PERPENDICULAR TO THE LOCAL ADVANCE ANGLE ****

RADIAL STATION	POT. LIFT	L. E. VORTEX	TIP VORTEX	AUGMENTED VORTEX	TOTAL LIFT
0.1000	0.0558	0.0000	0.0000	0.0000	0.0558
0.3000	0.1229	0.0000	0.0000	0.0000	0.1229
0.4000	0.1574	0.0000	0.0000	0.0000	0.1574
0.5000	0.1739	0.0000	0.0000	0.0000	0.1739
0.5500	0.1805	0.0000	0.0000	0.0000	0.1805
0.6000	0.1883	0.0000	0.0000	0.0000	0.1883
0.6500	0.1978	0.0000	0.0000	0.0000	0.1978
0.7000	0.2083	0.0000	0.0000	0.0000	0.2083
0.7500	0.2201	0.0000	0.0000	0.0000	0.2201
0.8000	0.2352	0.0001	0.0000	0.0000	0.2354
0.8250	0.2445	0.0003	0.0000	0.0000	0.2448
0.8500	0.2543	0.0008	0.0000	0.0000	0.2551
0.8750	0.2634	0.0017	0.0000	0.0000	0.2651
0.9000	0.2695	0.0032	0.0000	0.0000	0.2726
0.9250	0.2703	0.0052	0.0000	0.0000	0.2754
0.9500	0.2609	0.0071	0.0000	0.0082	0.2761
0.9600	0.2510	0.0075	0.0277	0.0137	0.2999
0.9700	0.2328	0.0074	0.0439	0.0163	0.3003
0.9800	0.2033	0.0064	0.0468	0.0155	0.2718
0.9900	0.1535	0.0041	0.0335	0.0104	0.2014
0.9980	0.0723	0.0010	0.0086	0.0026	0.0844
1.0000	0.0000	0.0000	0.0000	0.0000	0.0000

INCREMENTAL LIFTS AND DRAGS

RADIAL STATION	POT. LIFT	POT + LE VORT	POT + SE VORT	POT + AUGVORT	TOTAL LIFT
0.1000	0.0558	0.0558	0.0558	0.0558	0.0558
0.3000	0.1229	0.1229	0.1229	0.1229	0.1229
0.4000	0.1574	0.1574	0.1574	0.1574	0.1574
0.5000	0.1739	0.1739	0.1739	0.1739	0.1739
0.5500	0.1805	0.1805	0.1805	0.1805	0.1805
0.6000	0.1883	0.1883	0.1883	0.1883	0.1883
0.6500	0.1978	0.1978	0.1978	0.1978	0.1978
0.7000	0.2083	0.2083	0.2083	0.2083	0.2083
0.7500	0.2201	0.2201	0.2201	0.2201	0.2201
0.8000	0.2352	0.2354	0.2352	0.2352	0.2354
0.8250	0.2445	0.2448	0.2445	0.2445	0.2448
0.8500	0.2543	0.2551	0.2543	0.2543	0.2551
0.8750	0.2634	0.2651	0.2634	0.2634	0.2651
0.9000	0.2695	0.2726	0.2695	0.2695	0.2726
0.9250	0.2703	0.2754	0.2703	0.2703	0.2754
0.9500	0.2609	0.2680	0.2609	0.2691	0.2761
0.9600	0.2510	0.2586	0.2787	0.2647	0.2999
0.9700	0.2328	0.2402	0.2766	0.2491	0.3003
0.9800	0.2033	0.2097	0.2500	0.2187	0.2718
0.9900	0.1535	0.1576	0.1870	0.1639	0.2014
0.9980	0.0723	0.0733	0.0808	0.0748	0.0844
1.0000	0.0000	0.0000	0.0000	0.0000	0.0000

POT. DRAG	POT + LE VORT	POT + SE VORT	POT + AUGVORT	TOTAL DRAG
0.0079	0.0078	0.0078	0.0078	0.0078
0.0105	0.0093	0.0093	0.0093	0.0093
0.0117	0.0105	0.0105	0.0105	0.0105
0.0115	0.0115	0.0115	0.0115	0.0115
0.0107	0.0096	0.0096	0.0096	0.0096
0.0098	0.0094	0.0094	0.0094	0.0094
0.0092	0.0092	0.0092	0.0092	0.0092
0.0090	0.0089	0.0089	0.0089	0.0089
0.0089	0.0088	0.0088	0.0088	0.0088
0.0090	0.0089	0.0088	0.0088	0.0089
0.0090	0.0091	0.0089	0.0089	0.0091
0.0089	0.0093	0.0088	0.0088	0.0093
0.0084	0.0086	0.0075	0.0075	0.0086
0.0075	0.0069	0.0049	0.0049	0.0069
0.0062	0.0019	-0.0012	-0.0012	0.0019
0.0064	0.0024	-0.0018	-0.0013	0.0029
0.0069	0.0036	0.0008	0.0000	0.0060
0.0066	0.0049	0.0032	0.0016	0.0084
0.0062	0.0053	0.0044	0.0025	0.0090
0.0059	0.0046	0.0042	0.0028	0.0072
0.0061	0.0030	0.0029	0.0026	0.0037
0.0073	0.0024	0.0024	0.0024	0.0024

Figure 25C Program Output Listing : Vortexec Output (continued)

PERFORMANCE SUMMARY

ELEMENTAL PERFORMANCE

RADIAL * STATION	POTENTIAL		* POT+LEAD EDGE VORTEX *		POT+SIDE EDGE VORTEX *		POT+Augmented VORTEX *		TOTAL	
	DCP/DX	DCT/DX	DETA/DX	DETA/DX	DCP/DX	DCT/DX	DCP/DX	DCT/DX	DCP/DX	DETA/DX
0.1000	0.0375	-0.0047	-0.3918	0.0375	-0.0045	-0.3753	0.0375	-0.0045	-0.3753	-0.0045
0.3000	0.2606	0.0589	0.7013	0.7340	0.0615	0.7340	0.0615	0.7340	0.0615	0.7340
0.4000	0.5022	0.1283	0.7821	0.8139	0.1314	0.8139	0.1314	0.8139	0.1314	0.8139
0.5000	0.7625	0.2068	0.8409	0.8409	0.2068	0.8409	0.2068	0.8409	0.2068	0.8409
0.5500	0.8966	0.2501	0.8647	0.8782	0.2532	0.8782	0.2532	0.8782	0.2532	0.8782
0.6000	1.0330	0.2955	0.8867	0.8906	0.2965	0.8907	0.2965	0.8907	0.2965	0.8906
0.6500	1.1715	0.3407	0.9015	0.9015	0.3407	0.9015	0.3407	0.9015	0.3407	0.9015
0.7000	1.3104	0.3852	0.9112	0.9121	0.3854	0.9121	0.3854	0.9121	0.3854	0.9121
0.7500	1.4488	0.4292	0.9184	0.9193	0.4295	0.9194	0.4295	0.9194	0.4295	0.9193
0.8000	1.5819	0.4718	0.9245	0.9248	0.4721	0.9254	0.4721	0.9254	0.4721	0.9248
0.8250	1.6398	0.4906	0.9275	0.9280	0.4908	0.9280	0.4908	0.9280	0.4910	0.9264
0.8500	1.6825	0.5055	0.9314	0.9286	0.5057	0.9322	0.5057	0.9322	0.5062	0.9286
0.8750	1.6964	0.5129	0.9372	0.9367	0.5125	0.9369	0.5125	0.9369	0.5160	0.9367
0.9000	1.6622	0.5071	0.9456	0.9507	0.5145	0.9439	0.5145	0.9439	0.5145	0.9507
0.9250	1.5663	0.4825	0.9549	0.9864	0.5004	0.9864	0.5004	0.9864	0.5004	0.9864
0.9500	1.3924	0.4275	0.9517	0.9823	0.4465	0.9823	0.4465	0.9823	0.4465	0.9823
0.9600	1.2863	0.3928	0.9465	0.9727	0.4104	0.9727	0.4104	0.9727	0.4104	0.9727
0.9700	1.1356	0.3461	0.9447	0.9600	0.3601	0.9600	0.3601	0.9600	0.3601	0.9600
0.9800	0.9285	0.2847	0.9404	0.9507	0.2953	0.9507	0.2953	0.9507	0.2953	0.9507
0.9900	0.6687	0.1997	0.9257	0.9437	0.2071	0.9437	0.2071	0.9437	0.2071	0.9437
0.9980	0.3096	0.0844	0.8455	0.9218	0.0896	0.9218	0.0896	0.9218	0.0896	0.9218
1.0000	0.0287	-0.0090	-0.9737	0.0096	-0.0030	-0.9737	0.0096	-0.0030	-0.9737	-0.0030

ADVANCE RATIO = 3.1000

EFFICIENCY

	CP	CT
POTENTIAL LOADS ALONE	0.7517	0.2180
POTENTIAL + LEAD EDGE VORTEX	0.7534	0.2204
POTENTIAL + SIDE EDGE VORTEX	0.7553	0.2221
POTENTIAL + AUGMENTED VORTEX	0.7514	0.2210
TOTAL FOR ALL LOAD COMPONENTS	0.7643	0.2235

Figure 25D Program Output Listing : Vortexec Output (continued)

WITH CORRECTION FOR NON-LINEARITY

RADIUS = 0.7000 XBAR = 0.3910

PHI	POTENTIAL				VISCOUS				TOTAL	
	M/UO	U/UO	VX/VO	VT/VO	VR/VO	U/UO	VX/VO	VT/VO	VX/VO	VT/VO
-36.00	-0.4473E-01	-0.1367E-01	0.1807E-01	0.5443E-01	0.1170E-17	0.0000E+00	0.0000E+00	0.0000E+00	1.018	0.5443E-01
-34.00	-0.4468E-01	-0.1310E-01	0.1859E-01	0.5397E-01	0.9198E-03	0.0000E+00	0.0000E+00	0.0000E+00	1.019	0.5397E-01
-32.00	-0.4466E-01	-0.1254E-01	0.1915E-01	0.5356E-01	0.1840E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.019	0.5356E-01
-30.00	-0.4469E-01	-0.1198E-01	0.1972E-01	0.5319E-01	0.2759E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.020	0.5319E-01
-28.00	-0.4476E-01	-0.1145E-01	0.2030E-01	0.5288E-01	0.3679E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.020	0.5288E-01
-26.00	-0.4486E-01	-0.1095E-01	0.2087E-01	0.5262E-01	0.4599E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.021	0.5262E-01
-24.00	-0.4498E-01	-0.1048E-01	0.2143E-01	0.5242E-01	0.5519E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.021	0.5242E-01
-22.00	-0.4513E-01	-0.1006E-01	0.2195E-01	0.5227E-01	0.6438E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.022	0.5227E-01
-20.00	-0.4530E-01	-0.9692E-02	0.2244E-01	0.5217E-01	0.7358E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.022	0.5217E-01
-18.00	-0.4548E-01	-0.9371E-02	0.2289E-01	0.5213E-01	0.8278E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.023	0.5213E-01
-16.00	-0.4568E-01	-0.9102E-02	0.2330E-01	0.5213E-01	0.9198E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.023	0.5213E-01
-14.00	-0.4588E-01	-0.8887E-02	0.2366E-01	0.5219E-01	0.1012E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.024	0.5219E-01
-12.00	-0.4609E-01	-0.8731E-02	0.2397E-01	0.5229E-01	0.1104E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.024	0.5229E-01
-10.00	-0.4631E-01	-0.8635E-02	0.2422E-01	0.5244E-01	0.1196E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.024	0.5244E-01
-8.000	-0.4653E-01	-0.8602E-02	0.2441E-01	0.5264E-01	0.1288E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.024	0.5264E-01
-6.000	-0.4676E-01	-0.8636E-02	0.2453E-01	0.5288E-01	0.1380E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.025	0.5288E-01
-4.000	-0.4698E-01	-0.8743E-02	0.2459E-01	0.5318E-01	0.1472E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.025	0.5318E-01
-2.000	-0.4721E-01	-0.8933E-02	0.2455E-01	0.5354E-01	0.1564E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.025	0.5354E-01
0.0000E+00	-0.4743E-01	-0.9214E-02	0.2443E-01	0.5396E-01	0.1656E-01	0.0000E+00	0.0000E+00	0.0000E+00	0.9575	0.1014
2.000	-0.4764E-01	-0.9596E-02	0.2420E-01	0.5445E-01	0.1564E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.024	0.5445E-01
4.000	-0.4784E-01	-0.1009E-01	0.2385E-01	0.5500E-01	0.1472E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.024	0.5500E-01
6.000	-0.4802E-01	-0.1069E-01	0.2337E-01	0.5560E-01	0.1380E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.023	0.5560E-01
8.000	-0.4816E-01	-0.1141E-01	0.2275E-01	0.5626E-01	0.1288E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.023	0.5626E-01
10.00	-0.4825E-01	-0.1223E-01	0.2200E-01	0.5693E-01	0.1196E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.022	0.5693E-01
12.00	-0.4825E-01	-0.1311E-01	0.2112E-01	0.5755E-01	0.1104E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.021	0.5755E-01
14.00	-0.4815E-01	-0.1398E-01	0.2017E-01	0.5807E-01	0.1012E-01	0.0000E+00	0.0000E+00	0.0000E+00	1.020	0.5807E-01
16.00	-0.4793E-01	-0.1477E-01	0.1923E-01	0.5840E-01	0.9198E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.019	0.5840E-01
18.00	-0.4759E-01	-0.1539E-01	0.1837E-01	0.5851E-01	0.8278E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.018	0.5851E-01
20.00	-0.4718E-01	-0.1581E-01	0.1765E-01	0.5839E-01	0.7358E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.017	0.5839E-01
22.00	-0.4672E-01	-0.1601E-01	0.1713E-01	0.5808E-01	0.6438E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.017	0.5808E-01
24.00	-0.4627E-01	-0.1601E-01	0.1682E-01	0.5763E-01	0.5519E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.017	0.5763E-01
26.00	-0.4586E-01	-0.1584E-01	0.1669E-01	0.5710E-01	0.4599E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.017	0.5710E-01
28.00	-0.4551E-01	-0.1556E-01	0.1673E-01	0.5655E-01	0.3679E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.017	0.5655E-01
30.00	-0.4523E-01	-0.1518E-01	0.1691E-01	0.5599E-01	0.2759E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.017	0.5599E-01
32.00	-0.4501E-01	-0.1472E-01	0.1721E-01	0.5545E-01	0.1840E-02	0.0000E+00	0.0000E+00	0.0000E+00	1.017	0.5545E-01
34.00	-0.4484E-01	-0.1421E-01	0.1760E-01	0.5493E-01	0.9198E-03	0.0000E+00	0.0000E+00	0.0000E+00	1.018	0.5493E-01
36.00	-0.4473E-01	-0.1367E-01	0.1807E-01	0.5443E-01	0.1170E-17	0.0000E+00	0.0000E+00	0.0000E+00	1.018	0.5443E-01

Figure 26A Program Output Listing : Wakeexec Output

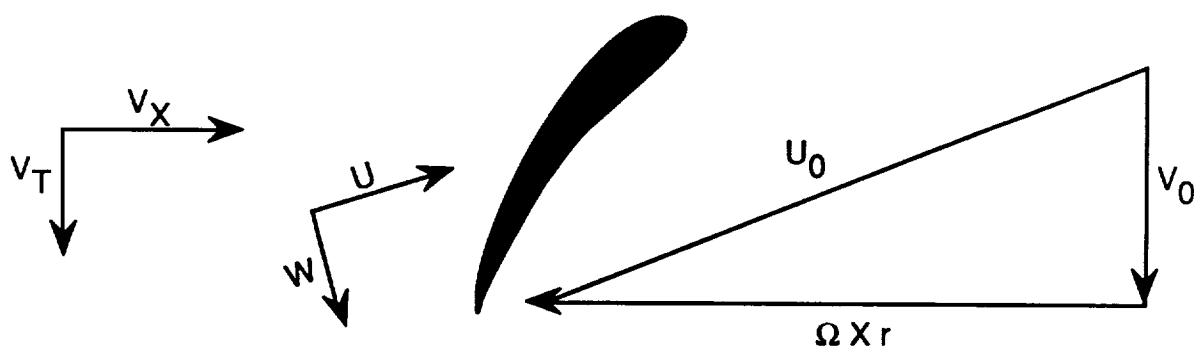


Figure 26B Wake exec output description

EXECUTE NOISE CALCULATION : NOZCLC NOIZEXEC EXECCASE TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

F091 - PROPELLER NOISE PREDICTION PROGRAM RUN INITIATED

OPERATING CONDITIONS:

0.7000	FLIGHT MACH NUMBER	0.7094	TIP ROTATIONAL MACH NUMBER	0.9966	TIP MACH NUMBER
59.00	TEMPERATURE, DEG F	1116.	SPEED OF SOUND, FT/SEC	617.4	HZ BPF
2.042	PROPELLER DIAMETER, FT.	5	NUMBER OF BLADES	0.9659	PAWB/2116
7408.	RPM				

CALCULATION INSTRUCTIONS:

0.1000	ROOT RADIUS RATIO	1.000	TIP RADIUS RATIO	1	NUMBER OF HARMONICS
			10+ 8 *KX/(2*PI) PTS CHORDWISE	4	DIRECTIVITY POINTS ANALYZED
22	NO. OF RAD. STATIONS ON BLADE		10+ 10PTS/CYCLE RADIAL INT	0	M EXTEND PTS(AUTOMATIC)
			0+ 0 PTS/CYCLE M INT		
0	NEAR FIELD ANALYSIS INDICATOR		1	DETAIL PRINT INDICATOR	
0	QUADRUPOLE TERM CALC. CODE				

DIRECTIVITY POINTS AT ALTITUDE OR SIDELINE DISTANCE, 4.000 FT.

DISTANCE FORWARD OF PLANE OF ROTATION (RETARDED)

8.708	3.921	0.8647	-1.900
-------	-------	--------	--------

DISTANCE FORWARD OF PLANE OF ROTATION (VISUAL)

2.000	0.0000E+00	-2.000	-5.000
-------	------------	--------	--------

RADIATION ANGLE FROM FLIGHT DIRECTION - DEGREES

24.67	45.57	77.80	115.4
-------	-------	-------	-------

VISUAL RADIATION ANGLE - DEGREES

63.43	90.00	116.6	141.3
-------	-------	-------	-------

BOUNDARY LAYER AND MAKE DISPLACEMENT THICKNESS ARE ADDED TO AIRFOIL THICKNESS

AZIMUTHAL DIRECTIVITY ANGLE = 0.0 DEG.

Figure 27A Program Output Listing : Noizexec Output

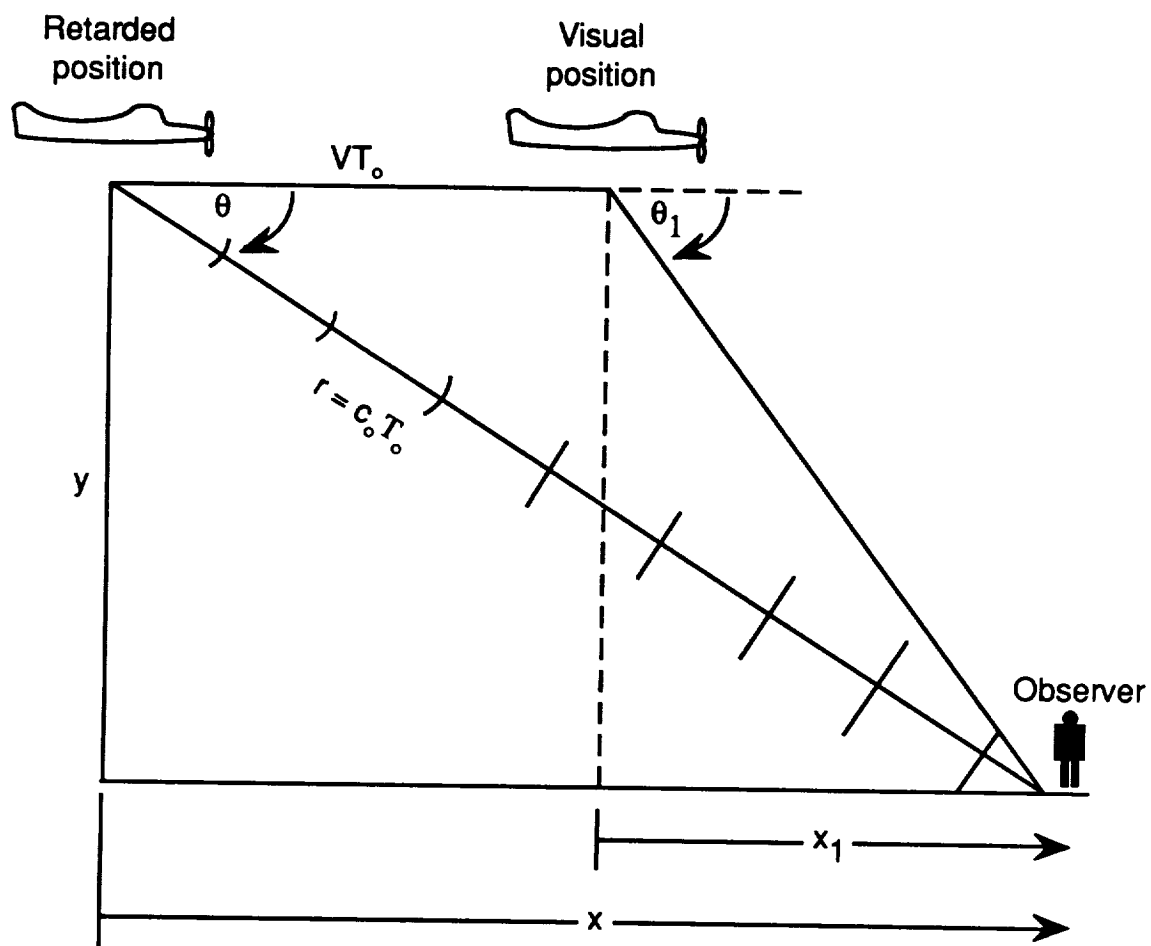
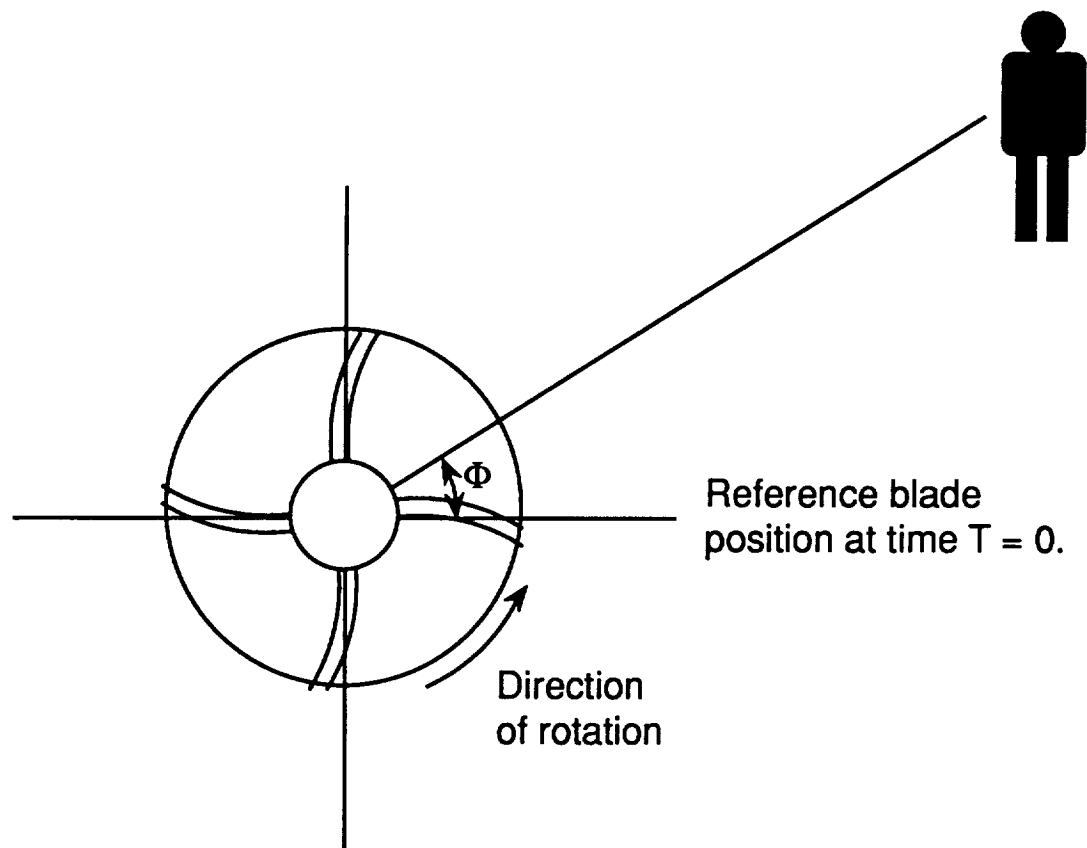


Figure 27B Visual and Retarded Location Relations
 (x and x_1 are positive in this example)



Unsteady loads are defined with respect to the reference blade position at time $T = 0$. The observer azimuthal position is defined by the angle Φ measured in the direction of rotation from the reference blade position.

Figure 27C Azimuthal observer angle.

```

OUTPUT NOISE CALC. RESULTS      : NOZSHS      NOIZEXEC  EXECCASE   TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA  1
*****
SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP
      BLADE ROW
J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.
EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE
*****

```

Figure 28 Program Output Listing : Noizexec Output

BLADE ELEMENT RESULTS FOR HARMONIC NUMBER 1
FREQUENCY IN HERTZ= 617.4, DIRECTIVITY POINT 1

RADIAL STATION INDEX	RANGE	KX	KY	PHASE SWEET	LAG DUE TO OFFSET	SUM OF 3 SOURCES			MONOPOLE		DIPOLE		QUADRUPOLE	
						AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP
1	0.10/0.16	4.82	12.92	30.3	11.8	0.000	243.6	0.000	236.8	0.000	257.6	0.000	90.0	0.000
2	0.16/0.22	4.78	8.44	12.0	2.2	0.001	216.3	0.001	209.1	0.000	244.0	0.000	90.0	0.000
3	0.22/0.28	4.72	6.01	-6.0	-2.4	0.002	195.2	0.002	186.9	0.000	253.3	0.000	90.0	0.000
4	0.28/0.34	4.68	4.49	-23.5	-4.3	0.005	178.2	0.005	167.9	0.001	269.8	0.000	90.0	0.000
5	0.34/0.40	4.84	3.54	-40.8	-3.5	0.009	161.9	0.009	151.7	0.002	243.4	0.000	90.0	0.000
6	0.40/0.46	4.93	2.75	-48.0	-2.8	0.015	156.3	0.015	145.7	0.003	234.2	0.000	90.0	0.000
7	0.46/0.52	4.98	2.07	-45.6	-2.1	0.024	159.8	0.024	149.0	0.005	241.7	0.000	90.0	0.000
8	0.52/0.58	4.92	1.47	-34.6	-1.0	0.037	172.0	0.038	161.7	0.007	259.6	0.000	90.0	0.000
9	0.58/0.64	4.73	0.92	-14.0	-0.3	0.053	193.9	0.054	184.2	0.009	284.4	0.000	90.0	0.000
10	0.64/0.70	4.44	0.46	13.6	0.1	0.070	221.6	0.071	213.6	0.010	315.0	0.000	90.0	0.000
11	0.70/0.76	4.10	0.09	47.0	0.1	0.092	252.7	0.092	248.4	0.007	345.9	0.000	90.0	0.000
12	0.76/0.82	3.70	-0.20	84.7	-0.4	0.115	285.6	0.115	287.1	0.003	196.1	0.000	90.0	0.000
13	0.82/0.88	3.20	-0.40	124.4	-1.0	0.130	317.3	0.132	327.6	0.024	227.0	0.000	90.0	0.000
14	0.88/0.94	2.58	-0.50	162.5	-1.8	0.123	336.9	0.127	5.5	0.062	257.5	0.000	90.0	0.000
15	0.94/1.00	1.84	-0.47	195.9	-2.5	0.112	350.0	0.092	41.6	0.091	297.5	0.000	90.0	0.000

RADIAL LOAD 1.42 -0.40 149.5 -2.6 0.000 45.0

SUM 0.413 288.2 0.228 298.8 0.193 275.8 0.000 45.0

RADIAL LOAD 0.000 45.0

BLADE TOTALS
PASCALS (RMS)

16.868 0.000

RADIAL LOAD

0.000

DB - NO INTERFERENCE

119.7 -409.2

RADIAL LOAD

-409.2

DECIBELS

RADIAL LOAD

118.5 -406.2

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM
J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

SUMMARY OF HARMONIC RESULTS FOR DIRECTIVITY 1
X = 8.708 , X1 = 2.000 , THETA = 24.67

HARMONIC ORDER	FREQ HZ	SUM OF 3 SOURCES		MONOPOLE		DIPOLE		QUADRUPOLE		RADIAL LOAD	
		DB	PASCALS	PHASE	DB	PASCALS	PHASE	DB	PASCALS	DB	PASCALS
1	617.4	125.1	36.029	288.2	120.0	19.888	298.8	118.5	16.868	275.8	-406.2
TOTALS		125.1	36.0	120.0	19.9	118.5	16.9	-406.2	0.0	-406.2	0.0

HARMONIC ORDER 1
INTEGRATION MESHES
JMAX 15
KK KEXTEND 0

Figure 29B Program Output Listing : Noizexec Output (continued)

BLADE ELEMENT RESULTS FOR HARMONIC NUMBER 1
FREQUENCY IN HERTZ= 617.4, DIRECTIVITY POINT 2

RADIAL STATION INDEX	RANGE	KX	KY	PHASE SWEEP	LAG DUE TO OFFSET	SUM OF 3 SOURCES AMP	PHASE	MONOPOLE AMP	PHASE	DIPOLE AMP	PHASE	QUADRUPOLE AMP	PHASE
1	0.10/0.16	3.44	13.10	21.6	11.9	0.000	169.3	0.000	157.3	0.000	188.5	0.000	90.0
2	0.16/0.22	3.41	8.71	8.5	2.2	0.001	148.3	0.001	134.8	0.000	183.3	0.000	90.0
3	0.22/0.28	3.36	6.36	-4.3	-2.5	0.003	134.2	0.003	117.5	0.001	191.5	0.000	90.0
4	0.28/0.34	3.34	4.91	-16.8	-4.7	0.006	125.2	0.006	103.4	0.002	198.1	0.000	90.0
5	0.34/0.40	3.45	4.06	-29.1	-4.1	0.011	116.2	0.010	92.4	0.005	179.8	0.000	90.0
6	0.40/0.46	3.52	3.37	-34.2	-3.4	0.019	115.1	0.017	88.7	0.009	174.0	0.000	90.0
7	0.46/0.52	3.55	2.78	-32.6	-2.8	0.032	119.5	0.027	91.6	0.015	179.4	0.000	90.0
8	0.52/0.58	3.51	2.25	-24.7	-1.6	0.047	130.4	0.041	101.2	0.023	192.4	0.000	90.0
9	0.58/0.64	3.37	1.76	-10.0	-0.5	0.063	149.3	0.056	118.0	0.033	210.7	0.000	90.0
10	0.64/0.70	3.17	1.33	9.7	0.3	0.079	173.5	0.068	139.7	0.044	233.3	0.000	90.0
11	0.70/0.76	2.93	0.96	33.5	0.9	0.097	198.9	0.081	165.3	0.053	256.4	0.000	90.0
12	0.76/0.82	2.64	0.65	60.4	1.1	0.114	224.6	0.093	193.6	0.059	278.9	0.000	90.0
13	0.82/0.88	2.28	0.39	88.8	0.9	0.122	251.2	0.096	223.0	0.058	301.8	0.000	90.0
14	0.88/0.94	1.84	0.19	115.9	0.7	0.102	272.9	0.083	250.4	0.041	324.3	0.000	90.0
15	0.94/1.00	1.31	0.05	139.8	0.3	0.064	298.0	0.054	278.4	0.022	352.6	0.000	90.0

RADIAL LOAD 1.01 0.01 106.7 0.0 0.000 45.0

SUM

0.448 213.2 0.349 180.4 0.244 264.0 0.000 45.0

RADIAL LOAD

BLADE TOTALS
PASCALS (RMS)

82.633 64.440 45.071 0.000

RADIAL LOAD

0.000

DB - NO INTERFERENCE

136.9 135.4 130.5 -409.2

RADIAL LOAD

-409.2

DECIBELS

132.3 130.2 127.1 -406.2

RADIAL LOAD

-406.2

Figure 29C Program Output Listing : Noizexec Output (continued)

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

SUMMARY OF HARMONIC RESULTS FOR DIRECTIVITY 2
X = 3.921 , X1 = 0.0000E+00, THETA = 45.57

HARMONIC ORDER	FREQ HZ	SUM OF 3 SOURCES DB PASCALS	MONOPOLE PHASE DB	DIPOLE PHASE DB	QUADRUPOLE PHASE DB	RADIAL LOAD PASCALS
1	617.4	132.3 82.633 213.2	130.2 64.440 180.4	127.1 45.071 264.0	45.0 -406.2 0.000	45.0
TOTALS		132.3 82.6 130.2 64.4	127.1 45.1	-406.2 0.0	-406.2 0.0	

HARMONIC ORDER 1
INTEGRATION MESHES
JHAX 15
KK KEXTEND 0

Figure 29D Program Output Listing : Noizexec Output (continued)

BLADE ELEMENT RESULTS FOR HARMONIC NUMBER 1
FREQUENCY IN HERTZ= 617.4, DIRECTIVITY POINT 3

RADIAL STATION INDEX	RANGE	KX	KY	PHASE SKEW	LAG DUE TO OFFSET	SUM OF 3 SOURCES			MONOPOLE		DIPOLE		QUADRUPOLE	
						AMP	PHASE		AMP	PHASE	AMP	PHASE	AMP	PHASE
1	0.10/0.16	2.06	13.28	12.9	12.1	0.000	236.0	0.000	209.7	90.0	0.000	257.0	0.000	90.0
2	0.16/0.22	2.04	8.97	5.1	2.3	0.000	223.6	0.000	192.4	90.0	0.000	255.9	0.000	90.0
3	0.22/0.28	2.01	6.70	-2.6	-2.7	0.001	219.4	0.001	180.1	90.0	0.001	260.0	0.000	90.0
4	0.28/0.34	2.00	5.33	-10.0	-5.1	0.002	220.8	0.002	170.9	90.0	0.002	261.6	0.000	90.0
5	0.34/0.40	2.07	4.58	-17.4	-4.6	0.005	218.0	0.003	164.9	90.0	0.004	250.9	0.000	90.0
6	0.40/0.46	2.11	3.98	-20.5	-3.5	0.011	219.8	0.005	163.5	90.0	0.009	247.8	0.000	90.0
7	0.46/0.52	2.12	3.49	-19.5	-2.2	0.019	224.7	0.008	165.8	90.0	0.016	251.2	0.000	90.0
8	0.52/0.58	2.10	3.04	-14.8	-0.8	0.030	234.2	0.013	172.4	90.0	0.027	259.5	0.000	90.0
9	0.58/0.64	2.02	2.60	-6.0	0.5	0.046	248.6	0.022	198.2	90.0	0.062	285.5	0.000	90.0
10	0.64/0.70	1.90	2.19	5.8	1.8	0.091	283.8	0.026	215.0	90.0	0.086	300.4	0.000	90.0
11	0.70/0.76	1.75	1.83	20.1	2.6	0.120	300.4	0.030	233.4	90.0	0.112	314.7	0.000	90.0
12	0.76/0.82	1.58	1.49	36.2	2.9	0.151	317.4	0.031	252.5	90.0	0.140	328.9	0.000	90.0
13	0.82/0.88	1.37	1.18	53.1	3.1	0.162	333.8	0.027	269.9	90.0	0.152	342.9	0.000	90.0
14	0.88/0.94	1.10	0.87	69.4	3.0	0.152	353.4	0.018	291.5	90.0	0.144	359.9	0.000	90.0
15	0.94/1.00	0.78	0.57	83.7										
RADIAL LOAD		0.60	0.42	63.8	2.7	0.000	45.0							
SUM						0.688	307.9	0.160	225.8		0.684	321.3	0.000	45.0
RADIAL LOAD		0.000			45.0									
BLADE TOTALS						62.977	14.628				62.662		0.000	
PASCALS (RMS)														
RADIAL LOAD		0.000				131.9	119.4				131.2		-409.2	
DB - NO INTERFERENCE														
RADIAL LOAD		-409.2				130.0	117.3				129.9		-406.2	
DECIBELS														
RADIAL LOAD		-406.2												

Figure 29E Program Output Listing : Noizexec Output (continued)

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROW

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE

FAR FIELD NOISE

SUMMARY OF HARMONIC RESULTS FOR DIRECTIVITY 3

X = 0.8647 , X1 = -2.000 , THETA = 77.80

HARMONIC ORDER	FREQ HZ	SUM OF 3 SOURCES		MONOPOLE		DIPOLE		QUADRUPOLE		RADIAL LOAD					
		DB	PASCALS	PHASE	DB	PASCALS	PHASE	DB	PASCALS	PHASE	DB	PASCALS			
1	617.4	130.0	62.977	307.9	117.3	14.628	225.8	129.9	62.662	321.3	-406.2	45.0	-406.2	0.000	45.0
TOTALS		130.0	63.0		117.3	14.6		129.9	62.7		-406.2	0.0	-406.2	0.0	

HARMONIC ORDER 1

INTEGRATION MESHES

JMAX 15

KK KEXTEND 0

Figure 29F Program Output Listing : Noizexec Output (continued)

BLADE ELEMENT RESULTS FOR HARMONIC NUMBER 1
FREQUENCY IN HERTZ= 617.4, DIRECTIVITY POINT 4

RADIAL STATION INDEX	RANGE	KX	KY	PHASE SWEEP	PHASE LAG DUE TO OFFSET	SUM OF 3 SOURCES AMP	PHASE	MONOPOLE AMP	PHASE	DIPOLE AMP	PHASE	QUADRUPOLE AMP	PHASE
1	0.10/0.16	1.35	13.38	8.5	12.2	0.000	315.9	0.000	273.0	0.000	331.9	0.000	90.0
2	0.16/0.22	1.34	9.11	3.3	2.3	0.000	308.9	0.000	258.4	0.000	329.9	0.000	90.0
3	0.22/0.28	1.32	6.87	-1.7	-2.8	0.001	309.0	0.000	248.8	0.000	331.1	0.000	90.0
4	0.28/0.34	1.31	5.55	-6.6	-5.3	0.001	311.6	0.000	242.2	0.001	330.9	0.000	90.0
5	0.34/0.40	1.35	4.85	-11.4	-4.9	0.003	309.1	0.001	239.0	0.003	324.1	0.000	90.0
6	0.40/0.46	1.38	4.30	-13.4	-4.4	0.007	310.0	0.002	238.9	0.007	322.2	0.000	90.0
7	0.46/0.52	1.39	3.85	-12.8	-3.8	0.014	313.4	0.003	241.1	0.013	324.6	0.000	90.0
8	0.52/0.58	1.38	3.44	-9.7	-2.5	0.024	320.2	0.004	246.2	0.023	330.5	0.000	90.0
9	0.58/0.64	1.32	3.03	-3.9	-0.9	0.039	330.0	0.006	254.9	0.038	338.8	0.000	90.0
10	0.64/0.70	1.24	2.63	3.8	0.6	0.061	341.7	0.008	266.0	0.059	348.9	0.000	90.0
11	0.70/0.76	1.15	2.27	13.1	2.2	0.090	353.4	0.009	278.8	0.088	359.4	0.000	90.0
12	0.76/0.82	1.04	1.93	23.7	3.4	0.126	4.4	0.011	292.5	0.123	9.4	0.000	90.0
13	0.82/0.88	0.90	1.58	34.8	3.8	0.170	15.2	0.012	306.9	0.166	19.1	0.000	90.0
14	0.88/0.94	0.72	1.22	45.5	4.4	0.203	25.7	0.011	319.5	0.198	28.6	0.000	90.0
15	0.94/1.00	0.51	0.83	54.8	4.4	0.208	37.9	0.008	339.4	0.204	39.9	0.000	90.0
RADIAL LOAD		0.40	0.63	41.8	4.0	0.000	45.0						
SUM						0.873	12.3	0.066	289.9	0.866	16.6	0.000	45.0
RADIAL LOAD				0.000	45.0								
BLADE TOTALS PASCALS (RMS)						6.370		0.482		6.325		0.000	
RADIAL LOAD				0.000									
DB - NO INTERFERENCE						110.8		88.9		110.6		-409.2	
RADIAL LOAD				-409.2									
DECIBELS RADIAL LOAD				-406.2		110.1		87.6		110.0		-406.2	

Figure 29G Program Output Listing : Noizexec Output (continued)

OUTPUT DIRECTIVITY RESULTS : NOZSMS NOIZEXEC EXECCASE TIME : HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROM

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VORTEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

SUMMARY OF HARMONIC RESULTS FOR DIRECTIVITY 4
X = -1.900 , X1 = -5.000 , THETA = 115.41

HARMONIC ORDER	FREQ HZ	SUM OF 3 SOURCES DB PASCALS	MONOPOLE PHASE DB PASCALS	DIPOLE PHASE DB PASCALS	QUADRUPOLE PHASE DB PASCALS	RADIAL LOAD PHASE DB PASCALS
1	617.4	110.1 6.370 12.3 87.6 0.482 289.9	110.0 6.325	16.6 -406.2	45.0 -406.2	0.000 45.0
TOTALS		110.1 6.4 87.6 0.5 110.0 6.3	-406.2	0.0	-406.2	0.0

HARMONIC ORDER 1
INTEGRATION MESHES
JMAX 15
KK KEXTEND 0

Figure 29H Program Output Listing : Noizexec Output (continued)

FINAL NOISE SUMMARY TABLE : NOZSMS NOIZEXEC EXECCASE TIME :HH:MM:SS DATE : MM/DD/YY UAAP --- NASA 1

SAMPLE PERFORMANCE CALCULATION FOR SRP VERSION OF UAAP

BLADE ROW

J = 3.10, M = 0.70, BETA 3/4 R = 55.45 DEG.

EDGE VOITEX GIVES LIFT, NOT RADIAL FORCE
FAR FIELD NOISE

DIRECTIVITY TABLE
ALTITUDE OR SIDELINE DISTANCE FROM PROP AXIS = 4.000

RETARDED X	8.71	3.92	0.86	-1.90
X/D	4.26	1.92	0.42	-0.93
THETA	24.67	45.57	77.80	115.41
VISUAL X1	2.00	0.00	-2.00	-5.00
X1/D	0.98	0.00	-0.98	-2.45
THETA1	63.43	90.00	116.57	141.34

HARMONIC

DECIBELS

1	TOTAL	125.1	132.3	130.0	110.1
	MONOPOLE	120.0	130.2	117.3	87.6
	DIPOLE	118.5	127.1	129.9	110.0
	QUADRUPOLE	-406.2	-406.2	-406.2	-406.2
	RADIAL DIP	-406.2	-406.2	-406.2	-406.2
OVERALL	TOTAL	125.1	132.3	130.0	110.1
	MONOPOLE	120.0	130.2	117.3	87.6
	DIPOLE	118.5	127.1	129.9	110.0
	QUADRUPOLE	-406.2	-406.2	-406.2	-406.2
	RADIAL DIP	-406.2	-406.2	-406.2	-406.2

CASE COMPLETED

PROGRAM TERMINATING NORMALLY

Figure 30 Program Output Listing : Noizexec Output (continued)

UAAP SYSTEM FILE REQUIREMENTS

File No.	Logical Record	Format	Description	Max Records
5	80 char.	F-F-N	Input data	250
6	132 char.	V-F-Y	Primary output	2500
8	10000 wds.	V-U-N	Temporary storage of K inverse matrix.	--
9	100 wds.	V-U-N	Temporary storage of Thickness vector.	--
11	80 char.	F-F-N	Temporary storage of input data.	250
44	80 char.	F-F-N	Temporary storage of Aero data for transfer to Vortex analysis section of code.	500
50	80 char.	F-F-N	Temporary storage of Aero and Vortex data for transfer to Noise analysis section of code.	500
51	1x10**6 wds.	V-U-N	Temporary file used in acoustic section.	--
52	1x10**6 wds.	V-U-N	Temporart file used in acoustic section.	--

Format : F-F-N Fixed record length with formatted records and no carriage control.

V-F-Y Variable record length with formatted records and carriage control.

V-U-N Variable record length with unformatted records and no carriage control.

Record Length : char. characters.
wds. words.

Figure 31 UAAP System File Requirements

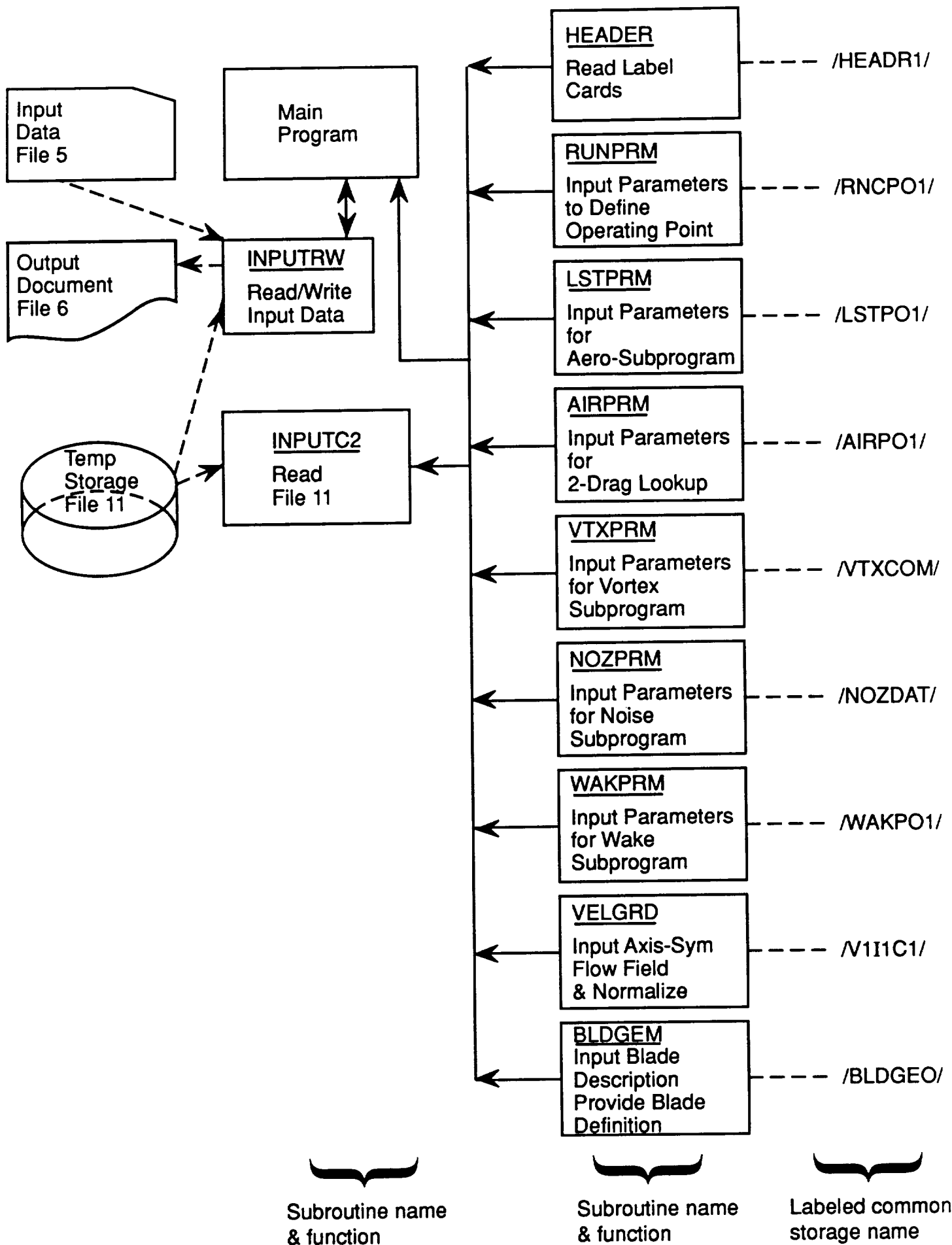


Figure 32 UAAP Input Data Storage Flowchart

Figure 33A Program Tree Structure



```

5      EXIT
4      INPTC2
3      NEWPG1
3      PRNTXX
3      EXIT
3      BLDCT3
4      PRNTIN
4      BDSA52
5      BDS024
6      BDS016
6      ERRSXT
7      BDS025
7      BDS026
7      BDS023
5      BDS053
5      BDS024
6      BDS016
6      ERRSXT
7      BDS025
7      BDS026
7      BDS023
5      BDS016
5      ERRSXT
5      GGS252
5      GGS253
5      GGS254
5      BDS054
4      EXIT
4      NEWPG1
4      PRNTXX
4      UNINT
3      BLDGP1
3      PRNTXX
1      NOZPRM
2      INPTC1
2      ENDJOB
2      EXIT
2      INPTC2
2      NEWPG1
2      PRNTXX
1      NOISEX
2      NOZCLC
3      NEWPG1
3      NOZINP
3      NOZCHK
4      NOZJ2
4      MNX
4      NOZKCC
4      BSINS
4      BSKES
4      BSJNS
4      BSYS
4      MNX
4      NOZAMP
5      BSINS
5      BSKES
5      BSJNS
5      BSYS
3      NOZFFC
3      NOZTRP
3      EXIT

```

"FREE-FIELD" READER.
PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE
PRINT ROUTINE FOR REAL OR INTEGER=4 VARIABLES

SETUP INPUT X-Y-Z COORD'S FOR BLADE CUTTING ROUTINE
PRINT INTEGER VARIABLES
CALCULATE "CUT" BLADE FROM 3-D INPUT X-Y-Z COORDINATES
PART OF BLADE STACKING ROUTINES

MACHINE DEPENDENT COMPUTATIONAL ERROR LIMIT (DUMMY)

PART OF BLADE STACKING ROUTINES

PART OF BLADE STACKING ROUTINES

MACHINE DEPENDENT COMPUTATIONAL ERROR LIMIT (DUMMY)

PART OF BLADE STACKING ROUTINES

MACHINE DEPENDENT COMPUTATIONAL ERROR LIMIT (DUMMY)

PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE
PRINT ROUTINE FOR REAL OR INTEGER=4 VARIABLES
UNIVARIATE INTERPOLATION OF REAL DATA
PRINT RXYCOORD BLADE GEOMETRY INPUT
PRINT ROUTINE FOR REAL OR INTEGER=4 VARIABLES
DEFAULT PARAMETERS AND INPUT FOR NOISE CALC
"FREE-FIELD" LOCATION DEPENDENT INPUT ROUTINE
TERMINATE PROGRAM -- BY CALLING EXIT.

"FREE-FIELD" READER.
PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE
PRINT ROUTINE FOR REAL OR INTEGER=4 VARIABLES
EXECUTE NOISE CALCULATION
CARRY OUT NOISE CALCULATION - EXECUTIVE ROUTINE
PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE
READS IN DATA FOR ACOUSTIC CALCULATION
CHECK AND WRITE OUT INPUTS
CALCULATE AUTOMATIC RADIAL INTEGRATION MESH SIZE
MAX/MIN OF REAL ARRAY
CALCULATE OMEGA INTEGRATION LIMITS FOR NEAR FIELD CALC
IMSL SUBROUTINE
IMSL SUBROUTINE
IMSL SUBROUTINE
IMSL SUBROUTINE
MAX/MIN OF REAL ARRAY
CALCULATE AMPLITUDE FUNCTION FOR NOZKCC
IMSL SUBROUTINE
IMSL SUBROUTINE
IMSL SUBROUTINE
IMSL SUBROUTINE
CALCULATE FAR FIELD HARMONIC NOISE LEVELS
LINEARLY INTERPOLATE NOISE CALCULATION QUANTITIES TO

```

4      NOZAIR
4      NOZMPL
4      NOZMHF
4      NOZHFL
4      UNLIN
4      NOZBLC
4      NOZQPL
4      BSJNS
4      NOZDPL
4      NOZRD
3      NOZMFC
3      EXIT
3      NOZTRP
3      EXIT
4      BSINS
4      BSKES
4      BSJNS
4      BSYS
4      NOZAIR
4      NOZMPL
4      NOZMHF
4      NOZHFL
4      UNLIN
4      NOZBLC
4      NOZQPL
4      NOZDPL
4      NOZRD
3      NOZSMS
3      NEWPG1
1      RUNPRM
2      INPTC1
2      ENDJOB
2      EXIT
2      INPTC2
2      NEWPG1
2      PRNTXX
2      ENDJOB
2      EXIT
1      HEADER
1      VTXP
2      NEWPG1
2      INPTC1
2      ENDJOB
2      EXIT
2      INPTC2
2      PRNTXX
1      ENDCAS
1      LSTPRM
2      INPTC1
2      ENDJOB
2      EXIT
2      INPTC2
2      NEWPG1
2      PRNTXX
2      PRNTCS
1      VELGRD
2      INPTC1
2      ENDJOB
2      EXIT
2      INPTC2
2      NEWPG1

```

FIND AIRFOIL TYPE AT Z
PROVIDES THICKNESS SOURCE MAGNITUDE AT A GIVEN RADIUS
CALC FOURIER TRANSFORM OF THICKNESS FOR AIRFOILS OTHER
THICKNESS FORMS FOR SERIES 4, 16, 64, 65 AND BICONVEX
LINEAR INTERPOLATION ROUTINE
CALCULATE FOURIER TRANSFORM OF BOUNDARY LAYER AND WAKE
'INSTANT' QUADRUPOLE NOISE SOURCE TERM
IMSL SUBROUTINE
ANALYTICAL FOURIER TRANSFORM OF CHORDWISE DELTA CP
ANAL. FOURIER TRANSFORM: REAL FUNCTION, MCP UNIFORM STEPS
CALCULATE NEAR FIELD HARMONIC NOISE LEVELS

LINEARLY INTERPOLATE NOISE CALCULATION QUANTITIES TO

IMSL SUBROUTINE
IMSL SUBROUTINE
IMSL SUBROUTINE
IMSL SUBROUTINE
FIND AIRFOIL TYPE AT Z
PROVIDES THICKNESS SOURCE MAGNITUDE AT A GIVEN RADIUS
CALC FOURIER TRANSFORM OF THICKNESS FOR AIRFOILS OTHER
THICKNESS FORMS FOR SERIES 4, 16, 64, 65 AND BICONVEX
LINEAR INTERPOLATION ROUTINE
CALCULATE FOURIER TRANSFORM OF BOUNDARY LAYER AND WAKE
'INSTANT' QUADRUPOLE NOISE SOURCE TERM
ANALYTICAL FOURIER TRANSFORM OF CHORDWISE DELTA CP
ANAL. FOURIER TRANSFORM: REAL FUNCTION, MCP UNIFORM STEPS
SUM NOISE VECTORS AND PRINT FINAL RESULTS
PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE
READ AND STORE DATA FOR DETERMINING FLIGHT CONDITION.
"FREE-FIELD" LOCATION DEPENDENT INPUT ROUTINE
TERMINATE PROGRAM -- BY CALLING EXIT.

"FREE-FIELD" READER.
PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE
PRINT ROUTINE FOR REAL OR INTEGER=4 VARIABLES
TERMINATE PROGRAM -- BY CALLING EXIT.

READ AND STORE PAGE HEADERS (TITLE CARDS)
INPUT AND DEFAULTS FOR VORTEX LIFT
PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE
"FREE-FIELD" LOCATION DEPENDENT INPUT ROUTINE
TERMINATE PROGRAM -- BY CALLING EXIT.

"FREE-FIELD" READER.
PRINT ROUTINE FOR REAL OR INTEGER=4 VARIABLES
END OF CASE -- SETUP FOR NEXT CASE.
READ AND PRINT LSTPARMS DATA
"FREE-FIELD" LOCATION DEPENDENT INPUT ROUTINE
TERMINATE PROGRAM -- BY CALLING EXIT.

"FREE-FIELD" READER.
PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE
PRINT ROUTINE FOR REAL OR INTEGER=4 VARIABLES
PRINT COMPLEX SINGLE PRECISION VARIABLES
INPUT AN AXSYMMETRIC FLOW FIELD.
"FREE-FIELD" LOCATION DEPENDENT INPUT ROUTINE
TERMINATE PROGRAM -- BY CALLING EXIT.

"FREE-FIELD" READER.
PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE

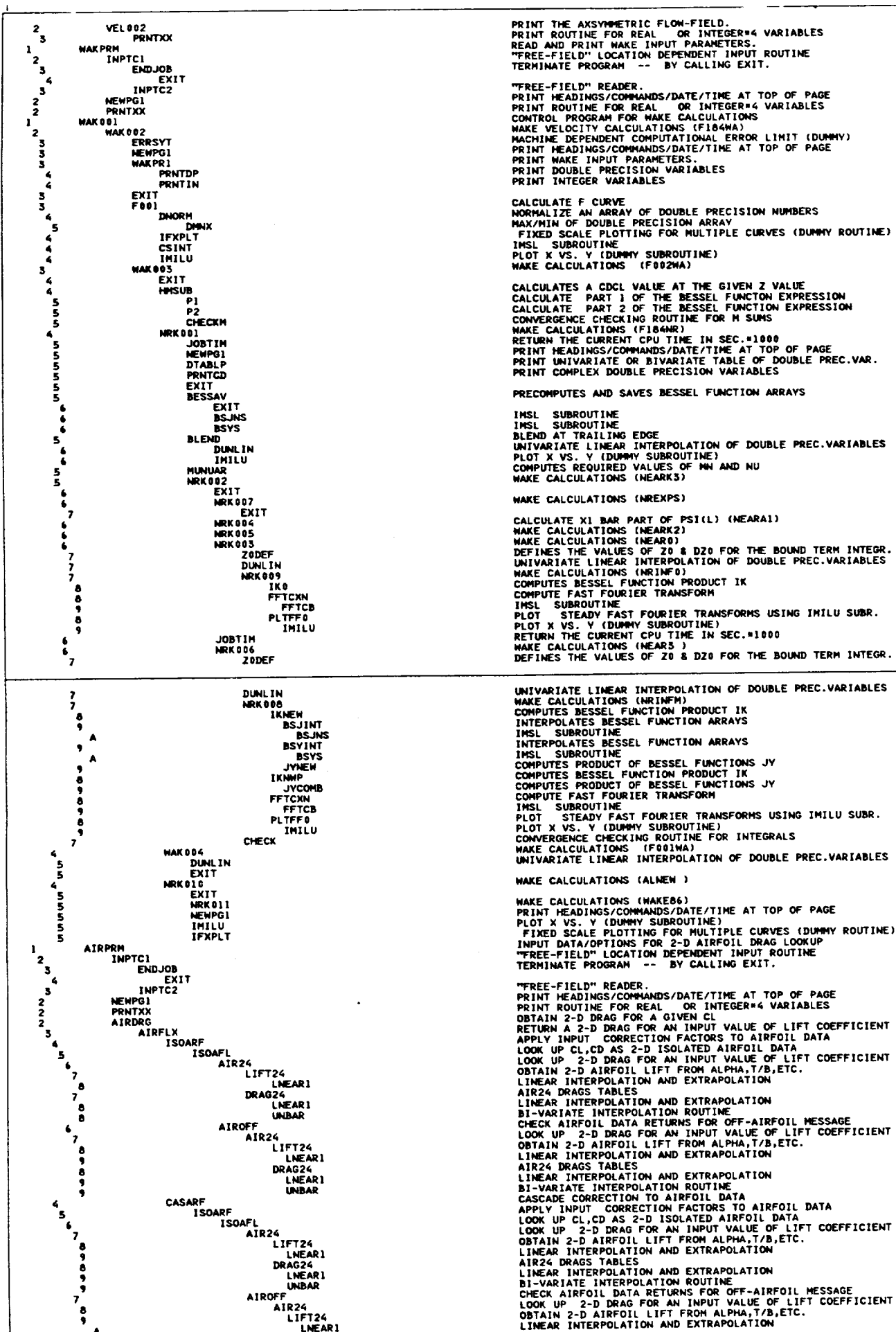


Figure 33C Program Tree Structure (continued)



Figure 33E Program Tree Structure (continued)

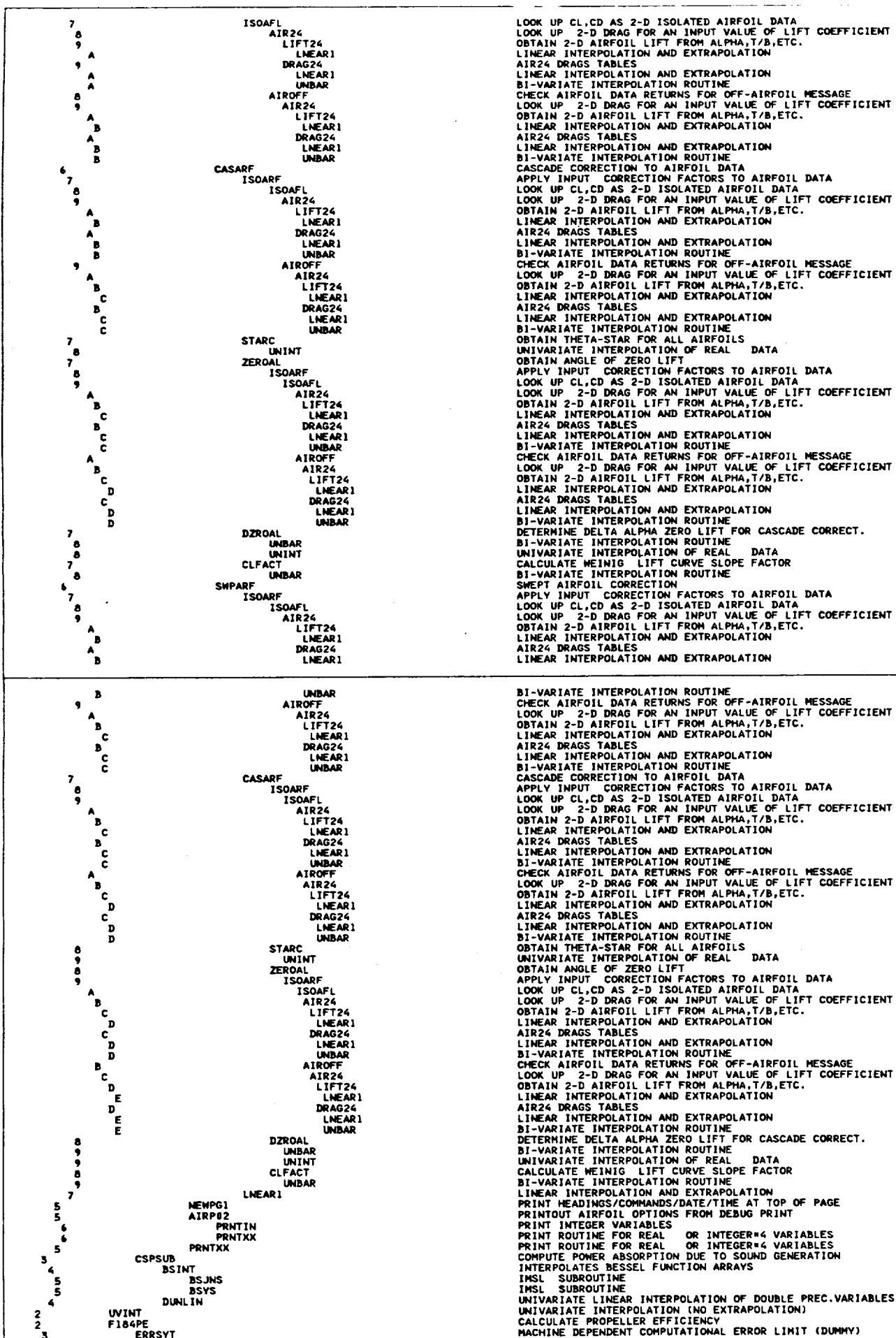


Figure 33G Program Tree Structure (continued)

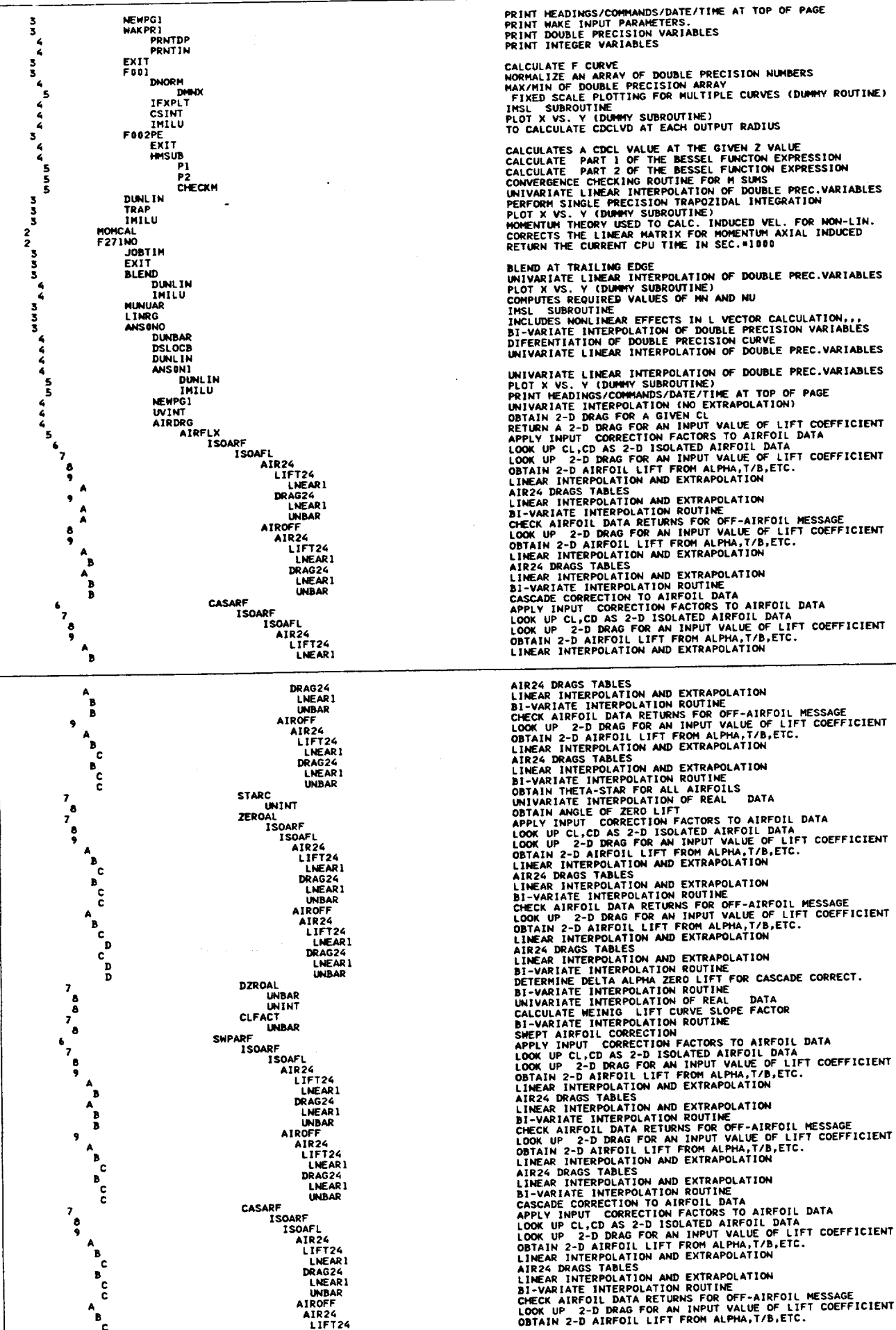


Figure 33H Program Tree Structure (continued)

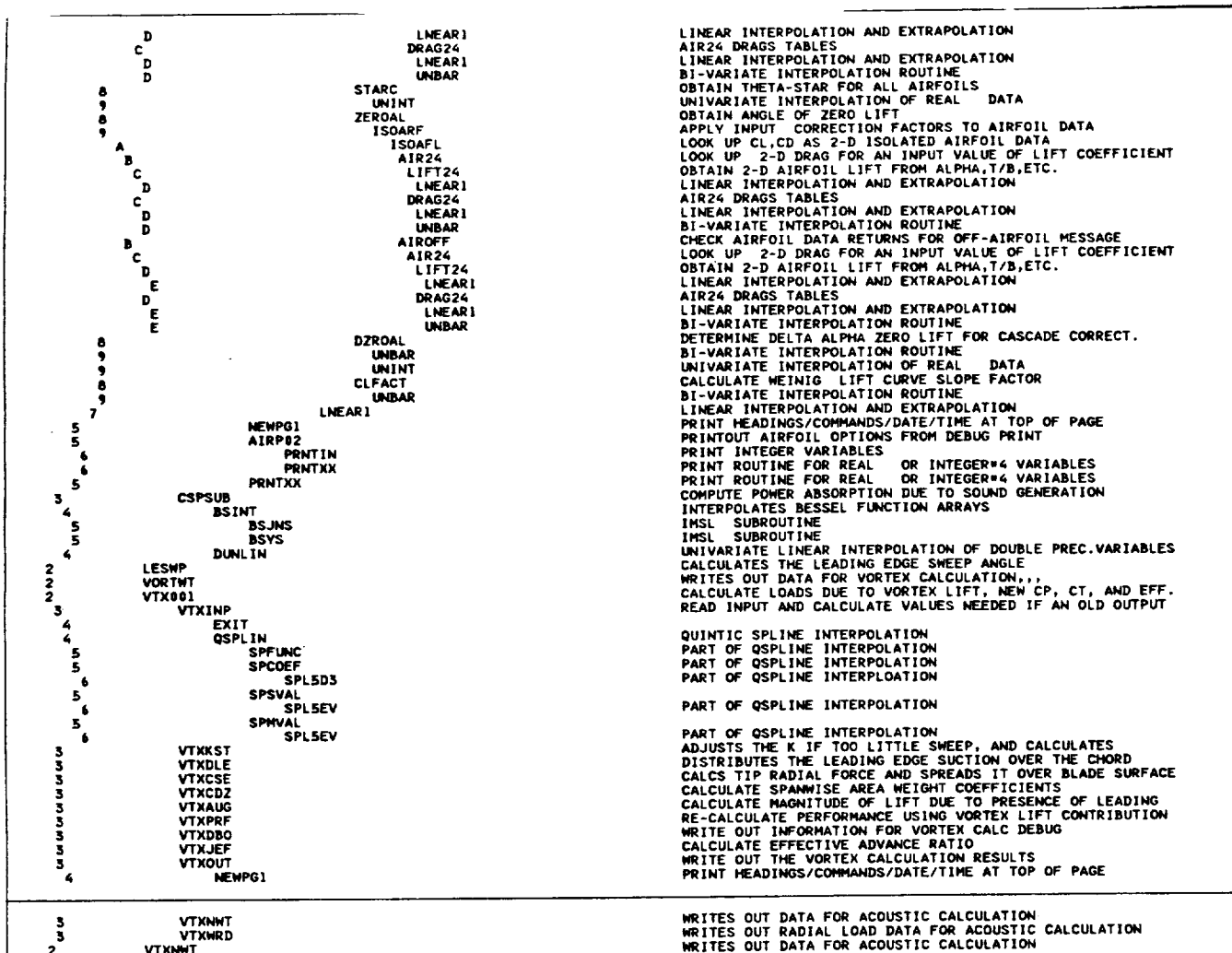


Figure 33I Program Tree Structure (continued)

SUBROUTINE	REFERENCE	AND	PURPOSE	LISTING
SUBROUTINE AIRDRG			PURPOSE :	OBTAIN 2-D DRAG FOR A GIVEN CL
SUBROUTINE AIRFLX			CALL (S) :	AIRFLX NEWPG1 AIRP02 PRNTXX
SUBROUTINE AIROFF			PURPOSE :	RETURN A 2-D DRAG FOR AN INPUT VALUE OF LIFT COEFFICIENT
SUBROUTINE AIRPRM			CALL (S) :	ISOARF CASARF SWPARF
SUBROUTINE AIRP02			PURPOSE :	CHECK AIRFOIL DATA RETURNS FOR OFF-AIRFOIL MESSAGE
SUBROUTINE AIR24			CALL (S) :	AIR24
SUBROUTINE ANS			PURPOSE :	INPUT DATA/OPTIONS FOR 2-D AIRFOIL DRAG LOOKUP
SUBROUTINE ANSN1			CALL (S) :	INPTC1 NEWPG1 PRNTXX AIRDRG
SUBROUTINE ANS0			PURPOSE :	PRINTOUT AIRFOIL OPTIONS FROM DEBUG PRINT
SUBROUTINE ANS0N0			CALL (S) :	PRNTIN PRNTXX
SUBROUTINE ANS0N1			PURPOSE :	LOOK UP 2-D DRAG FOR AN INPUT VALUE OF LIFT COEFFICIENT
SUBROUTINE ARCTAN			CALL (S) :	LIFT24 DRAG24
SUBROUTINE AIK2			PURPOSE :	COMPUTE UNSTEADY POTENTIAL LIFT AND PRESSURE DISTRIB.
SUBROUTINE BDSA52			CALL (S) :	LSTVVC DUNBAR DSLOCB DUNLIN ANSN1
SUBROUTINE BDS004			PURPOSE :	
SUBROUTINE BDS010			CALL (S) :	NEWPG1 DUNLIN IMILU
SUBROUTINE BDS011			PURPOSE :	COMPUTES STEADY POTENTIAL LIFT AND PRESSURE DISTR.
SUBROUTINE BDS012			CALL (S) :	LSTVVC DUNBAR DSLOCB DUNLIN ANS0N1 NEWPG1 UNINT AIRDRG
SUBROUTINE BDS013			PURPOSE :	INCLUDES NONLINEAR EFFECTS IN L VECTOR CALCULATION,,,
SUBROUTINE BDS014			CALL (S) :	DUNBAR DSLOCB DUNLIN ANS0N1 NEWPG1 UNINT AIRDRG
SUBROUTINE BDS015			PURPOSE :	
SUBROUTINE BDS016			CALL (S) :	DUNLIN IMILU
SUBROUTINE BDS018			PURPOSE :	COMPUTE THE ARC TANGENT OF Y/X BETWEEN 0 AND 2 PI.
SUBROUTINE BDS019			PURPOSE :	
SUBROUTINE BDS020			PURPOSE :	CALCULATE "CUT" BLADE FROM 3-D INPUT X-Y-Z CORRDINATES
SUBROUTINE BDS023			CALL (S) :	BDS024 BDS053 BDS016 GGS252 BDS054
SUBROUTINE BDS024			PURPOSE :	
SUBROUTINE BDS025			CALL (S) :	BDS015 BDS104
SUBROUTINE BDS026			PURPOSE :	
SUBROUTINE BDS052			CALL (S) :	CAMTHA
SUBROUTINE BDS053			PURPOSE :	
SUBROUTINE BDS054			CALL (S) :	BDS020
SUBROUTINE BDS086			PURPOSE :	INTERPOLATE OVER A 4 POINT INTERVAL USING A VARIATION
SUBROUTINE BDS088			PURPOSE :	USED FOR INTERPOLATION AND EXTRAP. OF CUBIC SPLINE FIT
SUBROUTINE BDS089			PURPOSE :	DEFINE AIRFOIL SHAPE
SUBROUTINE BDS095			CALL (S) :	MLINE CAMTHA BDS012 BDS024 BDS020
SUBROUTINE BDS096			CALL (S) :	BDS010 BDS018 HS1 PF1 HS2 H455S PF2 BDS011 BDS019 BDS013
SUBROUTINE BDS097			PURPOSE :	DEFINE BLADE SHAPE
SUBROUTINE BDS104			CALL (S) :	BDS014 BDS024
SUBROUTINE BESSAV			PURPOSE :	
SUBROUTINE BLDCT1			CALL (S) :	ERRSXT
SUBROUTINE BLDCT3			PURPOSE :	
SUBROUTINE BLDGEM			PURPOSE :	PROVIDE A PIECEWISE CUBIC SPLINE FIT OF THE DATA
SUBROUTINE BLDG11			PURPOSE :	INTERPOLATE OVER A 4 POINT INTERVAL
SUBROUTINE BLDG12			PURPOSE :	PART OF BLADE STACKING ROUTINES
SUBROUTINE BLDG13			PURPOSE :	PART OF BLADE STACKING ROUTINES
SUBROUTINE BLDGP1			CALL (S) :	BDS016 BDS025
SUBROUTINE BLEND			PURPOSE :	
SUBROUTINE BOUND			CALL (S) :	BDS026 BDS023
SUBROUTINE BOUND0			PURPOSE :	
SUBROUTINE BSINT			PURPOSE :	DEFINE BLADE COORD'S ON 2-D SURFACES
SUBROUTINE BSJINT			CALL (S) :	EXIT BDS004 GGS107 GGS011 BDS024 BDS053 BDS016 GGS252 BDS054
SUBROUTINE BSVINT			PURPOSE :	
SUBROUTINE CAMTHA			CALL (S) :	BDS024
SUBROUTINE CASARF			PURPOSE :	MODIFY THE AIRFOIL DATA BY CLOSING THE TRAILING/LEADING
SUBROUTINE CENTER			CALL (S) :	BDS096 BDS095 BDS089 BDS088
SUBROUTINE CHECK			PURPOSE :	GENERATE THE POINTS THAT CLOSE THE AIRFOIL,,,
SUBROUTINE CHECKM				
SUBROUTINE CLFACT				
SUBROUTINE CSPSUB				
SUBROUTINE CTRAP				
SUBROUTINE CUNLIN				
SUBROUTINE DEFZ0				
SUBROUTINE DMNX				
SUBROUTINE DMNH				
SUBROUTINE DRAG24				
SUBROUTINE DSLOCB				
SUBROUTINE DTABLP				
SUBROUTINE DUNBAR				
SUBROUTINE DUNLIN				
SUBROUTINE DZROAL				
SUBROUTINE ANS089			PURPOSE :	MODIFY THE AIRFOIL WITH A EDGE RADIUS LARGER
SUBROUTINE BDS095			CALL (S) :	BDS088
SUBROUTINE BDS096			PURPOSE :	FIND THE LINE SEGMENTS ON UPPER & LOWER SURFACES
SUBROUTINE BDS097			CALL (S) :	BDS097
SUBROUTINE BDS104			PURPOSE :	PRE & POST PROCESS INPUT & OUTPUT DATA SO THAT THE
SUBROUTINE BESSAV			PURPOSE :	FIND THE CIRCLE THAT IS TANGENT TO THREE LINES,
SUBROUTINE BLDCT1			PURPOSE :	
SUBROUTINE BLDCT3			CALL (S) :	BDS086
SUBROUTINE BLDGEM			PURPOSE :	PRECOMPUTES AND SAVES BESSEL FUNCTION ARRAYS
SUBROUTINE BLDG11			CALL (S) :	EXIT BSJNS BSYS
SUBROUTINE BLDG12			PURPOSE :	GENERATE BLADE SURFACE SHAPE & "CUT" BLADE (2-DCOORD)
SUBROUTINE BLDG13			CALL (S) :	QSPLIN UNINT NEWPG1 PRNTIN PRNTXX BDS052 EXIT UNINT
SUBROUTINE BLDGP1			PURPOSE :	SETUP INPUT X-Y-Z COORD'S FOR BLADE CUTTING ROUTINE
SUBROUTINE BLEND			CALL (S) :	PRNTIN BDSA52 EXIT NEWPG1 PRNTXX UNINT
SUBROUTINE BOUND			PURPOSE :	TOP LEVEL ROUTINE FOR BLADE GEOMETRY INPUT/CALCULATION
SUBROUTINE BOUND0			CALL (S) :	EXIT BLDG11 BLDG12 BLDG13
SUBROUTINE BSINT			PURPOSE :	INPUT DATA/CALCULATE BLADE GEOMETRY (2-D COORD OPTION)
SUBROUTINE BSJINT			CALL (S) :	INPTC1 NEWPG1 PRNTXX BLDCT1 BLDGP1
SUBROUTINE BSVINT			PURPOSE :	INPUT BLADE GEOMETRY IN R-X-Y FORMAT (RXYCOORD)
SUBROUTINE CAMTHA			CALL (S) :	INPTC1 NEWPG1 BLDGP1 UNINT
SUBROUTINE CASARF			PURPOSE :	INPUT BLADE GEOMETRY IN X-Y-Z FORMAT (XYZCOORD)
SUBROUTINE CENTER			CALL (S) :	INPTC1 NEWPG1 PRNTXX EXIT BLDCT3 BLDGP1
SUBROUTINE CHECK			PURPOSE :	PRINT RXYCOORD BLADE GEOMETRY INPUT
SUBROUTINE CHECKM			CALL (S) :	PRNTXX
SUBROUTINE CLFACT			PURPOSE :	BLEND AT TRAILING EDGE
SUBROUTINE CSPSUB			CALL (S) :	DUNLIN IMILU
SUBROUTINE CTRAP			PURPOSE :	COMPUTES UNSTEADY BOUND PART OF KERNAL FUNCTION
SUBROUTINE CUNLIN			CALL (S) :	SHWAK0 SHWAK DUNLIN IIEXYV DEFZ0 MSUM WING CENTER RADINT IMILU
SUBROUTINE DEFZ0			PURPOSE :	COMPUTES STEADY BOUND PART OF KERNAL FUNCTION
SUBROUTINE DMNX			CALL (S) :	DUNLIN IIEXP5 Z0DEF INFFN0
SUBROUTINE DMNH			PURPOSE :	INTERPOLATES BESSEL FUNCTION ARRAYS
SUBROUTINE DRAG24			CALL (S) :	BSJNS BSYS
SUBROUTINE DSLOCB			PURPOSE :	INTERPOLATES BESSEL FUNCTION ARRAYS
SUBROUTINE DTABLP			CALL (S) :	BSJNS
SUBROUTINE DUNBAR			PURPOSE :	INTERPOLATES BESSEL FUNCTION ARRAYS
SUBROUTINE DUNLIN			CALL (S) :	BSYS
SUBROUTINE DZROAL			PURPOSE :	DETERMINE CAMBER ANGLE FROM CAMBER
			CALL (S) :	EXIT
			PURPOSE :	CASCADE CORRECTION TO AIRFOIL DATA
			CALL (S) :	ISOARF STARC ZEROAL DZROAL CLFACT
			PURPOSE :	
			PURPOSE :	CONVERGENCE CHECKING ROUTINE FOR INTEGRALS
			PURPOSE :	CONVERGENCE CHECKING ROUTINE FOR M SUMS
			PURPOSE :	CALCULATE WEINIG LIFT CURVE SLOPE FACTOR
			CALL (S) :	UNBAR
			PURPOSE :	COMPUTE POWER ABSORPTION DUE TO SOUND GENERATION
			CALL (S) :	BSINT DUNLIN
			PURPOSE :	INTEGRATE A UNIVARIATE CURVE DEFINED BY A SERIES OF
			PURPOSE :	LINEAR INTERPOLATION OF A UNIVARIATE CURVE
			PURPOSE :	PRECOMPUTES RADIAL INTEGRATION STATIONS
			PURPOSE :	MAX/MIN OF DOUBLE PRECISION ARRAY
			PURPOSE :	NORMALIZE AN ARRAY OF DOUBLE PRECISION NUMBERS
			CALL (S) :	DMNX
			PURPOSE :	AIR24 DRAGS TABLES
			CALL (S) :	LINEAR1 UNBAR
			PURPOSE :	DIFFERENTIATION OF DOUBLE PRECISION CURVE
			PURPOSE :	PRINT UNIVARIATE OR BIVARIATE TABLE OF DOUBLE PREC.VAR.
			PURPOSE :	BI-VARIATE INTERPOLATION OF DOUBLE PRECISION VARIABLES
			PURPOSE :	UNIVARIATE LINEAR INTERPOLATION OF DOUBLE PREC.VARIABLES
			PURPOSE :	DETERMINE DELTA ALPHA ZERO LIFT FOR CASCADE CORRECT.
			CALL (S) :	UNBAR UNINT

Figure 34A Subroutine References

SUBROUTINE ENDCAS	PURPOSE : END OF CASE -- SETUP FOR NEXT CASE.
SUBROUTINE ENDJOB	PURPOSE : TERMINATE PROGRAM -- BY CALLING EXIT.
	CALL (S) : EXIT
SUBROUTINE ERSXT	PURPOSE : MACHINE DEPENDENT COMPUTATIONAL ERROR LIMIT (DUMMY)
SUBROUTINE ERSYT	PURPOSE : MACHINE DEPENDENT COMPUTATIONAL ERROR LIMIT (DUMMY)
SUBROUTINE FEXP	PURPOSE : COMPUTE E**X
SUBROUTINE FFTCX	PURPOSE : FAST FOURIER TRANSFORM
	CALL (S) : FFTCB
SUBROUTINE FFTCXN	PURPOSE : COMPUTE FAST FOURIER TRANSFORM
	CALL (S) : FFTCB
SUBROUTINE FFTCX0	PURPOSE : FAST FOURIER TRANSFORM
	CALL (S) : FFTCB
SUBROUTINE FFUN	PURPOSE : THIS ROUTINE INTERPOLATES THE F CURVE AT Z
SUBROUTINE F001	PURPOSE : CALCULATE F CURVE
	CALL (S) : DNORM IFXPLT CSINT IMILU
SUBROUTINE F002PE	PURPOSE : TO CALCULATE CDCLVD AT EACH OUTPUT RADIUS
	CALL (S) : EXIT HNSUB
SUBROUTINE F184PE	PURPOSE : CALCULATE PROPELLER EFFICIENCY
	CALL (S) : ERSYT NEWPG1 WAKPR1 EXIT F001 F002PE DUNLIN TRAP IMILU
SUBROUTINE F271	PURPOSE : CALLS ROUTINE TO GENERATE K AND WT.
	CALL (S) : JOBTIM NEWPG1 PRNTDP PRNTIN DTABLP PRNTCD EXIT DUNLIN BESSAV BLEND
	CALL (S) : MUNUAR KMATRX KMATR0 THICK ANS ANS0 CSPSUB
SUBROUTINE F271WO	PURPOSE : CORRECTS THE LINEAR MATRIX FOR MOMENTUM AXIAL INDUCED
	CALL (S) : JOBTIM EXIT BLEND MUNUAR LINRG ANS0NO CSPSUB
SUBROUTINE GGS011	PURPOSE : TRANSFORMATION FROM X,Y,Z TO XS,YS,ZS
SUBROUTINE GGS107	PURPOSE : CALCULATES ROTATIONAL COEFFICIENTS TO CONVERT 3-D
SUBROUTINE GGS252	PURPOSE :
	CALL (S) : GGS253 GGS254
SUBROUTINE GGS253	PURPOSE :
SUBROUTINE GGS254	PURPOSE :
SUBROUTINE HEADER	PURPOSE : READ AND STORE PAGE HEADERS (TITLE CARDS)
SUBROUTINE HNSUB	PURPOSE : CALCULATES A CDCL VALUE AT THE GIVEN Z VALUE
	CALL (S) : P1 P2 CHECKM
SUBROUTINE HS1	PURPOSE : GENERATE HS1 AIRFOIL COORDINATES (DUMMY ROUTINE)
	CALL (S) : EXIT
SUBROUTINE HS2	PURPOSE : GENERATE HS2 AIRFOIL COORDINATES (DUMMY ROUTINE)
	CALL (S) : EXIT
SUBROUTINE H455S	PURPOSE :
	CALL (S) : EXIT
SUBROUTINE IFXPLT	PURPOSE : FIXED SCALE PLOTTING FOR MULTIPLE CURVES (DUMMY ROUTINE)
SUBROUTINE IIEXP5	PURPOSE : PRECOMPUTE PART OF II ASSOCIATED WITH CHW
	CALL (S) : EXIT
SUBROUTINE IIEXYV	PURPOSE : TO CALCULATE THE W RANGE AND THE IIMBAR,NBAR) ARRAY
	CALL (S) : EXIT
SUBROUTINE IKCOMB	PURPOSE : USED FOR IK COMBINT'N AND SUMS 3 & 4 IN THE Q=0 SINGLR. REG.
SUBROUTINE IKNEW	PURPOSE : COMPUTES BESSEL FUNCTION PRODUCT IK
	CALL (S) : BSJINT BSYINT JYNEW
SUBROUTINE IKNWP	PURPOSE : COMPUTES BESSEL FUNCTION PRODUCT IK
	CALL (S) : JYCOMB
SUBROUTINE IKPCMB	PURPOSE : COMPUTE I * K' BESSEL FUNCTION USING DEBYE'S ASSYMTOTIC EXPLAN.
SUBROUTINE IKSUB	PURPOSE : COMPUTES BESSEL FUNCTION PRODUCT IK
	CALL (S) : IKNEW JYCOMB
SUBROUTINE IKSUB0	PURPOSE : COMPUTES BESSEL FUNCTION PRODUCT IK
	CALL (S) : BSYS SPECIN
SUBROUTINE IK0	PURPOSE : COMPUTES BESSEL FUNCTION PRODUCT IK
SUBROUTINE IMILU	PURPOSE : PLOT X VS. Y (DUMMY SUBROUTINE)
SUBROUTINE IMNSIN	PURPOSE : COMPUTES IMN INTEGRAL
SUBROUTINE IMNSUB	PURPOSE : COMPUTE IMN INTEGRAL
SUBROUTINE INF	PURPOSE : COMPUTES IMN INTEGRAL
	CALL (S) : IKNEW TIKSUB TIK0 FFTCX0 PLTFF0
SUBROUTINE INFFNS	PURPOSE : COMPUTES IMN INTEGRAL
	CALL (S) : IKSUB IKSUB0 FFTCX R4ARAY PLTFFT
SUBROUTINE INFFN0	PURPOSE : COMPUTES IMN INTEGRAL
	CALL (S) : IKNEW IKNWP IK0 FFTCX0 PLTFF0
SUBROUTINE INPTC1	PURPOSE : "FREE-FIELD" LOCATION DEPENDENT INPUT ROUTINE
	CALL (S) : ENDJOB INPTC2
SUBROUTINE INPTC2	PURPOSE : "FREE-FIELD" READER.
SUBROUTINE INPTRW	PURPOSE : READ FROM FILE 5 AND EHC0 THE INPUT TO FILE 11
	CALL (S) : NEWPG1
SUBROUTINE IPKCHB	PURPOSE : COMPUTE I' * K BESSEL FUNCTION USING DEBYE'S ASSYMTOTIC EXPLAN.
SUBROUTINE ISOAFL	PURPOSE : LOOK UP CL,CD AS 2-D ISOLATED AIRFOIL DATA
	CALL (S) : AIR24 AIROFF
SUBROUTINE ISOARF	PURPOSE : APPLY INPUT CORRECTION FACTORS TO AIRFOIL DATA
	CALL (S) : ISOAFL
SUBROUTINE JOBTIM	PURPOSE : RETURN THE CURRENT CPU TIME IN SEC.=1000
SUBROUTINE JYCOMB	PURPOSE : COMPUTES PRODUCT OF BESSEL FUNCTIONS JY
SUBROUTINE JYNEW	PURPOSE : COMPUTES PRODUCT OF BESSEL FUNCTIONS JY
SUBROUTINE KMATRX	PURPOSE : COMPUTES MATRIX OF UNSTEADY INFLUENCE COEFFICIENTS
	CALL (S) : DUNLIN AIK2 JOBTIM WAKE BOUND LINCG
SUBROUTINE KMATR0	PURPOSE : COMPUTES MATRIX OF STEADY INFLUENCE COEFFICIENTS
	CALL (S) : AIK2 DUNLIN WAKM0 BOUND0 JOBTIM WAKEQ0 BOUND LINRG
SUBROUTINE LESWP	PURPOSE : CALCULATES THE LEADING EDGE SWEEP ANGLE
SUBROUTINE LIFT24	PURPOSE : OBTAIN 2-D AIRFOIL LIFT FROM ALPHA,T/D,ETC.
	CALL (S) : LINEAR1
SUBROUTINE LNEAR1	PURPOSE : LINEAR INTERPOLATION AND EXTRAPOLATION
SUBROUTINE LSTALS	PURPOSE : CONTROL PROGRAM FOR AERO LOADS CALCULATIONS
	CALL (S) : VORTWT VTX001 VTXNMT
	CALL (S) : NEWPG1 PRNTXX LSTSW1 DUNLIN F271 UVINT F184PE MOMCAL F271NO LESWP
SUBROUTINE LSTCGA	PURPOSE : CALCULATE CGA AND FA FROM X,Y, AND Z.
SUBROUTINE LSTPRM	PURPOSE : READ AND PRINT LSTPARMS DATA
	CALL (S) : INPTC1 NEWPG1 PRNTXX PRNTCS
SUBROUTINE LSTSW1	PURPOSE : CALCULATE AERODYNAMIC BLADE SWEEP.
	CALL (S) : QSPLIN LSTCGA LSTXYZ
SUBROUTINE LSTVVC	PURPOSE : INTERPOLATE THE AXSYMMETRIC FLOWFIELD FOR LST
	CALL (S) : NEWPG1 PRNTXX PRNTIN PRNTDP DUNLIN VEL003
SUBROUTINE LSTXYZ	PURPOSE : CALCULATE X,Y, AND Z FROM CGA, AND FA.
SUBROUTINE MAIN	PURPOSE :
	CALL (S) : VTXPRM ENDCAS LSTPRM VELGRD WAKPRM WAK001 AIRPRM LSTALS
	CALL (S) : INKIN DATE CLOCK INPTRW BLDGEM NOZPRM NOISEX RUNPRM ENDJOB HEADER
SUBROUTINE MLINE	PURPOSE : CALCULATE AIRFOIL MEANLINES
	CALL (S) : BDS019 BDS013
SUBROUTINE MNX	PURPOSE : MAX/MIN OF REAL ARRAY
SUBROUTINE MOMCAL	PURPOSE : MOMENTUM THEORY USED TO CALC. INDUCED VEL. FOR NON-LIN.
SUBROUTINE MSUM	PURPOSE : COMPUTES M SERIES IN KERNEL
	CALL (S) : INFFNS CHECK
SUBROUTINE MUNUAR	PURPOSE : COMPUTES REQUIRED VALUES OF MN AND NU
SUBROUTINE NEWPG1	PURPOSE : PRINT HEADINGS/COMMANDS/DATE/TIME AT TOP OF PAGE
SUBROUTINE NOISEX	PURPOSE : EXECUTE NOISE CALCULATION
	CALL (S) : NOZCLC
SUBROUTINE NOZAIR	PURPOSE : FIND AIRFOIL TYPE AT Z
SUBROUTINE NOZAMP	PURPOSE : CALCULATE AMPLITUDE FUNCTION FOR NOZKKC
	CALL (S) : BSINS BSKE5 WSJNS BSYS
SUBROUTINE NOZBLC	PURPOSE : CALCULATE FOURIER TRANSFORM OF BOUNDARY LAYER AND WAKE
SUBROUTINE NOZCHK	PURPOSE : CHECK AND WRITE OUT INPUTS
	CALL (S) : NOZNJ2 NOZKKC
SUBROUTINE NOZCLC	PURPOSE : CARRY OUT NOISE CALCULATION - EXECUTIVE ROUTINE
	CALL (S) : NEWPG1 NOZINP NOZCHK NOZFFC NOZNFC NOZSMS
SUBROUTINE NOZDPL	PURPOSE : ANALYTICAL FOURIER TRANSFORM OF CHORDWISE DELTA CP
SUBROUTINE NOZFFC	PURPOSE : CALCULATE FAR FIELD HARMONIC NOISE LEVELS
	CALL (S) : NOZTRP NOZAIR NOZMPL NOZBLC NOZOPL BSJNS NOZDPL NOZRD1
SUBROUTINE NOZHFL	PURPOSE : THICKNESS FORMS FOR SERIES 4, 16, 64, 65 AND BICONVEX
SUBROUTINE NOZINP	PURPOSE : READS IN DATA FOR ACOUSTIC CALCULATION

Figure 34B Subroutine References (continued)

SUBROUTINE NOZKKC	PURPOSE : CALCULATE OMEGA INTEGRATION LIMITS FOR NEAR FIELD CALC
SUBROUTINE NOZMPL	CALL (S) : BSINS BSKE5 BSJNS BSYS MNX NOZAMP
SUBROUTINE NOZMFC	PURPOSE : PROVIDES THICKNESS SOURCE MAGNITUDE AT A GIVEN RADIUS
	CALL (S) : NOZMHF
	PURPOSE : CALCULATE NEAR FIELD HARMONIC NOISE LEVELS
	CALL (S) : NOZDPL NOZRDL
	CALL (S) : EXIT NOZTRP BSINS BSKE5 BSJNS BSYS NOZAIR NOZMPL NOZBLC NOZQPL
SUBROUTINE NOZMHF	PURPOSE : CALC FOURIER TRANSFORM OF THICKNESS FOR AIRFOILS OTHER
	CALL (S) : NOZHFL UNLIN
SUBROUTINE NOZJ2	PURPOSE : CALCULATE AUTOMATIC RADIAL INTEGRATION MESH SIZE
	CALL (S) : MNX
SUBROUTINE NOZPRM	PURPOSE : DEFAULT PARAMETERS AND INPUT FOR NOISE CALC
	CALL (S) : INPTC1 NEWPG1 PRNTXX
SUBROUTINE NOZQPL	PURPOSE : 'INSTANT' QUADRUPOLE NOISE SOURCE TERM
SUBROUTINE NOZRDL	PURPOSE : ANAL. FOURIER TRANSFORM: REAL FUNCTION, NCP UNIFORM STEPS
SUBROUTINE NOZSMS	PURPOSE : SUM NOISE VECTORS AND PRINT FINAL RESULTS
	CALL (S) : NEWPG1
SUBROUTINE NOZTRP	PURPOSE : LINEARLY INTERPOLATE NOISE CALCULATION QUANTITIES TO
	CALL (S) : EXIT
SUBROUTINE NRK001	PURPOSE : WAKE CALCULATIONS (F184NR)
	CALL (S) : JOBTIM NEWPG1 DTABLP PRNTCD EXIT BESSAV BLEND MUNUAR NRK002
SUBROUTINE NRK002	PURPOSE : WAKE CALCULATIONS (NEARK3)
	CALL (S) : EXIT NRK007 NRK004 NRK005 NRK003 JOBTIM NRK006
SUBROUTINE NRK003	PURPOSE : WAKE CALCULATIONS (NEAR0)
	CALL (S) : ZODEF DUNLIN NRK009
SUBROUTINE NRK004	PURPOSE : CALCULATE X1 BAR PART OF PSI(L) (NEARA1)
SUBROUTINE NRK005	PURPOSE : WAKE CALCULATIONS (NEARK2)
SUBROUTINE NRK006	PURPOSE : WAKE CALCULATIONS (NEAR3)
	CALL (S) : ZODEF DUNLIN NRK008 CHECK
SUBROUTINE NRK007	PURPOSE : WAKE CALCULATIONS (NREXPS)
	CALL (S) : EXIT
SUBROUTINE NRK008	PURPOSE : WAKE CALCULATIONS (NRINFM)
	CALL (S) : IKNEW IKNMP FFTCXN PLTFF0
SUBROUTINE NRK009	PURPOSE : WAKE CALCULATIONS (NRINF0)
	CALL (S) : IK0 FFTCXN PLTFF0
SUBROUTINE NRK010	PURPOSE : WAKE CALCULATIONS (ALNEW)
	CALL (S) : EXIT NRK011 NEWPG1 IMILU IFXPLT
SUBROUTINE NRK011	PURPOSE : WAKE CALCULATIONS (MAKE86)
SUBROUTINE PF1	PURPOSE : GENERATE PF1 AIRFOIL COORDINATES (DUMMY ROUTINE)
	CALL (S) : EXIT
SUBROUTINE PF2	PURPOSE : GENERATE PF2 AIRFOIL COORDINATES (DUMMY ROUTINE)
	CALL (S) : EXIT
SUBROUTINE PLTFFT	PURPOSE : PLOT UNSTEADY FAST FOURIER TRANSFORMS USING IMILU SUBR.
	CALL (S) : IMILU
SUBROUTINE PLTFF0	PURPOSE : PLOT STEADY FAST FOURIER TRANSFORMS USING IMILU SUBR.
	CALL (S) : IMILU
SUBROUTINE PRNTCD	PURPOSE : PRINT COMPLEX DOUBLE PRECISION VARIABLES
SUBROUTINE PRNTCS	PURPOSE : PRINT COMPLEX SINGLE PRECISION VARIABLES
SUBROUTINE PRNTDP	PURPOSE : PRINT DOUBLE PRECISION VARIABLES
SUBROUTINE PRNTIN	PURPOSE : PRINT INTEGER VARIABLES
SUBROUTINE PRNTXX	PURPOSE : PRINT ROUTINE FOR REAL OR INTEGER*4 VARIABLES
SUBROUTINE PSIK2	PURPOSE : TO CALCULATE THE PSIV ARRAY
SUBROUTINE P1	PURPOSE : CALCULATE PART 1 OF THE BESSEL FUNCTION EXPRESSION
SUBROUTINE P2	PURPOSE : CALCULATE PART 2 OF THE BESSEL FUNCTION EXPRESSION
SUBROUTINE QSPLIN	PURPOSE : QUINTIC SPLINE INTERPOLATION
	CALL (S) : SPFUNC SPCOE5 SPSVAL SPMVAL
SUBROUTINE RADINT	PURPOSE : PERFORMS RADIAL INTEGRATION
	CALL (S) : EXIT CUNLIN CTRAP
SUBROUTINE RJF	PURPOSE : FUNCTION TO COMPUTE RJ AND DERIVATES
SUBROUTINE RUNPRM	PURPOSE : READ AND STORE DATA FOR DETERMINING FLIGHT CONDITION.
	CALL (S) : INPTC1 NEWPG1 PRNTXX

SUBROUTINE R4ARAY	PURPOSE : TAKES 2 COMPLEX ARRAYS FROM FFT AND MAKES +/- REAL ARRAYS
SUBROUTINE SMWAK	PURPOSE : ROUTINE TO DEFINE THE ELEMENT IN THE WAKE KERNEL TO WHICH
SUBROUTINE SMWAK0	PURPOSE : ROUTINE TO DEFINE THE ELEMENT IN THE WAKE KERNEL TO WHICH
SUBROUTINE SPCOE5	PURPOSE : PART OF QSPLINE INTERPOLATION
	CALL (S) : SPLSD3
SUBROUTINE SPECIN	PURPOSE : TO CALCULATE THE EFFECTIVE HEIGHT OF A SLICE
SUBROUTINE SPFUNC	PURPOSE : PART OF QSPLINE INTERPOLATION
SUBROUTINE SPLSD3	PURPOSE : PART OF QSPLINE INTERPOLATION
SUBROUTINE SPLSEV	PURPOSE : PART OF QSPLINE INTERPOLATION
SUBROUTINE SPMVAL	PURPOSE : SPLSEV
	CALL (S) : SPLSEV
SUBROUTINE SPSVAL	PURPOSE : SPLSEV
	CALL (S) : SPLSEV
SUBROUTINE STARC	PURPOSE : OBTAIN THETA-STAR FOR ALL AIRFOILS
	CALL (S) : UNINT
SUBROUTINE SUM1	PURPOSE : COMPUTES SUM1 IN WAKE KERNAL
SUBROUTINE SUM2	PURPOSE : COMPUTES SUM2 IN WAKE KERNAL
SUBROUTINE SUM3	PURPOSE : COMPUTES SUM3 IN WAKE KERNAL
	CALL (S) : IKPCMB IPKCM5
SUBROUTINE SUM4	PURPOSE : COMPUTES SUM4 IN WAKE KERNAL
	CALL (S) : IKCOMB
SUBROUTINE SUM5	PURPOSE : COMPUTES SUM5 IN WAKE KERNAL
	CALL (S) : IKCOMB
SUBROUTINE SUM6	PURPOSE : COMPUTES SUM6 IN WAKE KERNAL
SUBROUTINE SNPAPF	PURPOSE : SWEPT AIRFOIL CORRECTION
	CALL (S) : ISOARF CASARF LNEAR1
SUBROUTINE THICK	PURPOSE : COMPUTE THICKNESS VECTOR
	CALL (S) : PSIK2 THICK0 THICK3
SUBROUTINE THICK0	PURPOSE : COMPUTE THICKNESS VECTOR
	CALL (S) : DUNLIN I1EXPS ZODEF INF
SUBROUTINE THICK3	PURPOSE : COMPUTE THICKNESS VECTOR
	CALL (S) : DUNLIN I1EXPS ZODEF INF CHECK
SUBROUTINE TIKSUB	PURPOSE :
SUBROUTINE TIK0	PURPOSE :
SUBROUTINE TRAP	PURPOSE : PERFORM SINGLE PRECISION TRAPEZOIDAL INTEGRATION
SUBROUTINE UNBAR	PURPOSE : BI-VARIATE INTERPOLATION ROUTINE
SUBROUTINE UNINT	PURPOSE : UNIVARIATE INTERPOLATION OF REAL DATA
SUBROUTINE UNLIN	PURPOSE : LINEAR INTERPOLATION ROUTINE
SUBROUTINE UVINT	PURPOSE : UNIVARIATE INTERPOLATION (NO EXTRAPOLATION)
SUBROUTINE VELGRD	PURPOSE : INPUT AN AXSYMMETRIC FLOW FIELD.
	CALL (S) : INPTC1 NEWPG1 VEL002
SUBROUTINE VEL002	PURPOSE : PRINT THE AXSYMMETRIC FLOW-FIELD.
	CALL (S) : PRNTXX
SUBROUTINE VEL003	PURPOSE : INTERPOLATE THE AXSYMMETRIC FLOWFIELD.
	CALL (S) : EXIT NEWPG1 PRNTDP PRNTXX PRNTIN BDS024
SUBROUTINE VORTEX	PURPOSE : EXECUTE VORTEX CALCULATION
	CALL (S) : VTXX001
SUBROUTINE VORTWT	PURPOSE : WRITES OUT DATA FOR VORTEX CALCULATION...
SUBROUTINE VTXXAUG	PURPOSE : CALCULATE MAGNITUDE OF LIFT DUE TO PRESENCE OF LEADING
SUBROUTINE VTXXCD2	PURPOSE : CALCULATE SPANWISE AREA WEIGHT COEFFICIENTS
SUBROUTINE VTXXCE	PURPOSE : CALC5 TIP RADIAL FORCE AND SPRE-DS IT OVER BLADE SURFACE
SUBROUTINE VTXXDB0	PURPOSE : WRITE OUT INFORMATION FOR VORTEX CALC DEBUG
SUBROUTINE VTXXDLE	PURPOSE : DISTRIBUTES THE LEADING EDGE SUCTION OVER THE CHORD
SUBROUTINE VTXXINP	PURPOSE : READ INPUT AND CALCULATE VALUES NEEDED IF AN OLD OUTPUT
	CALL (S) : EXIT QSPLIN
SUBROUTINE V1XJEF	PURPOSE : CALCULATE EFFECTIVE ADVANCE RATIO
SUBROUTINE VTXXST	PURPOSE : ADJUSTS THE K IF TOO LITTLE SWEEP, AND CALCULATES
SUBROUTINE VTXXNNT	PURPOSE : WRITES OUT DATA FOR ACOUSTIC CALCULATION
SUBROUTINE VTXXOUT	PURPOSE : WRITE OUT THE VORTEX CALCULATION RESULTS
	CALL (S) : NEWPG1
SUBROUTINE VTXXPRF	PURPOSE : RE-CALCULATE PERFORMANCE USING VORTEX LIFT CONTRIBUTION

Figure 34C Subroutine References (continued)

SUBROUTINE VTXPRM	PURPOSE : INPUT AND DEFAULTS FOR VORTEX LIFT
	CALL (S) : NEWPG1 INPTC1 PRNTXX
SUBROUTINE VTXWRD	PURPOSE : WRITES OUT RADIAL LOAD DATA FOR ACOUSTIC CALCULATION
SUBROUTINE VTX001	PURPOSE : CALCULATE LOADS DUE TO VORTEX LIFT, NEW CP, CT, AND EFF.
	CALL (S) : VTXNNT VTXWRD
	CALL (S) : VTXINP VTXKST VTXDLE VTXCSE VTXCDZ VTXAUG VTXPRF VTXDBO VTKJEF VTXOUT
SUBROUTINE WAKE	PURPOSE : SUBROUTINE TO GENERATE THE INTEGRATED MATRIX ELEMENTS
	CALL (S) : EXIT DUNLIN BSINS BSKE5 IKCOMB CHECK IMNSUB WAKESN
SUBROUTINE WAKE00	PURPOSE : TO GENERATE THE INTEGRATED MATRIX ELEMENTS
	CALL (S) : EXIT DUNLIN BSINS BSKE5 CHECK IMNSUB WAKES0
SUBROUTINE WAKESN	PURPOSE : SUBROUTINE TO GENERATE THE INTEGRATED MATRIX ELEMENTS
	CALL (S) : DUNLIN SUM1 CHECK SUM2 SUM3 SUM4 SUM5 SUM6 IMNSIN
SUBROUTINE WAKES0	PURPOSE : TO GENERATE THE INTEGRATED MATRIX ELEMENTS
	CALL (S) : DUNLIN IKPCMB IKPCMB CHECK IKCOMB IMNSIN
SUBROUTINE WAKM0	PURPOSE : TO GENERATE THE INTEGRATED MATRIX ELEMENTS
	CALL (S) : DUNLIN WAKM01
SUBROUTINE WAKM01	PURPOSE : TO GENERATE THE INTEGRATED MATRIX ELEMENTS
	CALL (S) : DUNLIN IMNSIN
SUBROUTINE WAKPRM	PURPOSE : READ AND PRINT WAKE INPUT PARAMETERS.
	CALL (S) : INPTC1 NEWPG1 PRNTXX
SUBROUTINE WAKPRI	PURPOSE : PRINT WAKE INPUT PARAMETERS.
	CALL (S) : PRNTDP PRNTIN
SUBROUTINE WAK001	PURPOSE : CONTROL PROGRAM FOR WAKE CALCULATIONS
	CALL (S) : WAK002
SUBROUTINE WAK002	PURPOSE : WAKE VELOCITY CALCULATIONS (F184WA)
	CALL (S) : ERRSYT NEWPG1 WAKPRI EXIT F001 WAK003
SUBROUTINE WAK003	PURPOSE : WAKE CALCULATIONS (F002WA)
	CALL (S) : EXIT HNSUB NRK001 WAK004 NRK010
SUBROUTINE WAK004	PURPOSE : WAKE CALCULATIONS (F001WA)
	CALL (S) : DUNLIN EXIT
SUBROUTINE WING	PURPOSE : COMPUTES WING KERNEL NEAR SINGULARITY
	CALL (S) : WINGIN
SUBROUTINE WINGF	PURPOSE : COMPUTES WING KERNEL NEAR SINGULARITY
	CALL (S) : BSYS
SUBROUTINE WINGIN	PURPOSE : COMPUTES WING KERNEL NEAR SINGULARITY
	CALL (S) : WINGF FFTCX R4ARAY PLTFFT
SUBROUTINE ZEROAL	PURPOSE : OBTAIN ANGLE OF ZERO LIFT
	CALL (S) : ISOARF
SUBROUTINE Z0DEF	PURPOSE : DEFINES THE VALUES OF Z0 & DZ0 FOR THE BOUND TERM INTEGR.

Figure 34D Subroutine References (continued)

SUBROUTINE CROSS REFERENCE LISTING

SUBR. SUBROUTINE NAMES

AIRDRG IS CALLED BY : AIRPRM ANS0 ANS0NO
 AIRFLX IS CALLED BY : AIRDRG
 AIROFF IS CALLED BY : ISOAFL
 AIRPRM IS CALLED BY : MAIN
 AIRP02 IS CALLED BY : AIRDRG
 AIR24 IS CALLED BY : AIROFF ISOAFL
 ANS IS CALLED BY : F271
 ANSN1 IS CALLED BY : ANS
 ANS0 IS CALLED BY : F271
 ANS0NO IS CALLED BY : F271NO
 ANSN1 IS CALLED BY : ANS0 ANS0NO
 ARCTAM IS CALLED BY :
 AIK2 IS CALLED BY : KMATRIX KMATR0
 BDSA52 IS CALLED BY : BLDCT3
 BDS004 IS CALLED BY : BDS052
 BDS010 IS CALLED BY : BDS014
 BDS011 IS CALLED BY : BDS014
 BDS012 IS CALLED BY : BDS014
 BDS013 IS CALLED BY : BDS014 MLINE
 BDS014 IS CALLED BY : BDS015
 BDS015 IS CALLED BY : BDS004
 BDS016 IS CALLED BY : BDSA52 BDS052 BDS024
 BDS018 IS CALLED BY : BDS014
 BDS019 IS CALLED BY : BDS014 MLINE
 BDS020 IS CALLED BY : BDS011 BDS014
 BDS023 IS CALLED BY : BDS025
 BDS024 IS CALLED BY : VEL003 BDSA52 BDS014 BDS015 BDS052 BDS053
 BDS025 IS CALLED BY : BDS024
 BDS026 IS CALLED BY : BDS025
 BDS052 IS CALLED BY : BLDCT1
 BDS053 IS CALLED BY : BDSA52 BDS052
 BDS054 IS CALLED BY : BDSA52 BDS052
 BDS086 IS CALLED BY : BDS184
 BDS088 IS CALLED BY : BDS086 BDS089
 BDS089 IS CALLED BY : BDS086
 BDS095 IS CALLED BY : BDS086
 BDS096 IS CALLED BY : BDS086
 BDS097 IS CALLED BY : BDS095
 BDS104 IS CALLED BY : BDS004
 BESSAV IS CALLED BY : F271 NRK001
 BLDCT1 IS CALLED BY : BLDG11
 BLDCT3 IS CALLED BY : BLDG13
 BLDGEM IS CALLED BY : MAIN
 BLDG11 IS CALLED BY : BLDGEM
 BLDG12 IS CALLED BY : BLDGEM
 BLDG13 IS CALLED BY : BLDGEM
 BLDGP1 IS CALLED BY : BLDG11 BLDG12 BLDG13
 BLEND IS CALLED BY : F271 F271NO NRK001
 BOUND IS CALLED BY : KMATRIX KMATR0
 BOUND0 IS CALLED BY : KMATR0
 BSINT IS CALLED BY : CSPSUB
 BSJINT IS CALLED BY : IKNEW
 BSYINT IS CALLED BY : IKNEW
 CAMTHA IS CALLED BY : BDS010 BDS014
 CASARF IS CALLED BY : AIRFLX SHPARF
 CENTER IS CALLED BY : BOUND

CHECK IS CALLED BY : NRK006 THICKS WAKE0 WAKES0 WAKE WAKESN MSUM
 CHECKM IS CALLED BY : HMSUB
 CLFACT IS CALLED BY : CASARF
 CSPSUB IS CALLED BY : F271 F271NO
 CTRAP IS CALLED BY : RADINT
 CUNLIN IS CALLED BY : RADINT
 DEFZ0 IS CALLED BY : BOUND
 DMN0 IS CALLED BY : DNORM
 DNORM IS CALLED BY : F001
 DRAG24 IS CALLED BY : AIR24
 DSLOCB IS CALLED BY : ANS0 ANS0NO ANS
 DTABL P IS CALLED BY : F271 NRK001
 DUNBAR IS CALLED BY : ANS0 ANS0NO ANS
 DUNLIN IS CALLED BY : WAKES0 WAKM0 WAKM01 ANS ANSN1 ANSN1 BLEND BOUND BOUND0 CSPSUB
 : KMATRIX KMATR0 WAKE WAKESN WAK004 LSTALS
 : LSTVVC F104PE F271 NRK003 NRK006 ANS0 ANS0NO THICK0 THICKS WAKE00

DZROAL IS CALLED BY : CASARF
 ENDCAS IS CALLED BY : MAIN
 ENDJOB IS CALLED BY : MAIN INPTC1
 ERRSXT IS CALLED BY : BDS016
 ERRSYT IS CALLED BY : F104PE WAK002
 FEXP IS CALLED BY :
 FFTCX IS CALLED BY : INFFNS WINGIN
 FFTC0N IS CALLED BY : NRK008 NRK001
 FFTCX0 IS CALLED BY : INF INFFN0
 FFUN IS CALLED BY :
 F001 IS CALLED BY : F104PE WAK002
 F002PE IS CALLED BY : F104PE
 F104PE IS CALLED BY : LSTALS
 F271 IS CALLED BY : LSTALS
 F271NO IS CALLED BY : LSTALS
 GOS011 IS CALLED BY : BDS052
 GOS107 IS CALLED BY : BDS052
 GOS252 IS CALLED BY : BDSA52 BDS052
 GOS253 IS CALLED BY : GOS252
 GOS254 IS CALLED BY : GOS252
 HEADER IS CALLED BY : MAIN
 HMSUB IS CALLED BY : F002PE WAK003
 HS1 IS CALLED BY : BDS014
 HS2 IS CALLED BY : BDS014
 H455S IS CALLED BY : BDS014
 IFXPLT IS CALLED BY : F001 NRK010
 IIEXP5 IS CALLED BY : THICK0 THICK3 BOUND0
 IIEXYX IS CALLED BY : BOUND
 IKCOMB IS CALLED BY : SUMS WAKES0 WAKE
 IKNEW IS CALLED BY : NRK008 IKSUB INF INFFN0
 IKMWP IS CALLED BY : NRK008 INFFN0
 IKPCMB IS CALLED BY : SUMS WAKES0
 IKSUB IS CALLED BY : INFFNS
 IKSUB0 IS CALLED BY : INFFNS
 IK0 IS CALLED BY : NRK009 INFFN0
 IMLU IS CALLED BY : F104PE F001 NRK010 PLTFFT PLTFF0 ANSN1 ANSN1 BLEND BOUND
 IMNSIN IS CALLED BY : WAKES0 WAKM01 WAKESN
 IMNSUB IS CALLED BY : WAKE0 WAKE
 INF IS CALLED BY : THICK0 THICK3
 INFFNS IS CALLED BY : MSUM
 INFFN0 IS CALLED BY : BOUND0
 INPTC1 IS CALLED BY : RUNPRM VTXPRM BLDG11 BLDG12 BLDG13 LSTPRM VELGRD WAKPRM AIRPRM NOZPRM
 INPTC2 IS CALLED BY : INPTC1
 INPTRM IS CALLED BY : MAIN
 IPKCHB IS CALLED BY : SUMS WAKES0

Figure 35A Subroutine Cross References

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ISOAFL IS CALLED BY : ISOARF
ISOARF IS CALLED BY : AIRFLX CASARF SWPARF ZEROAL
JOBTIM IS CALLED BY : F271 F271NO MRK001 MRK002 KMATRIX KMATRO
JYCOMB IS CALLED BY : IKSUB IKMWP
JYNEH IS CALLED BY : IKNEW
KMATRIX IS CALLED BY : F271
KMATRO IS CALLED BY : F271
LESWP IS CALLED BY : LSTALS
LIFT24 IS CALLED BY : AIR24
LNEAR1 IS CALLED BY : DRAG24 LIFT24 SWPARF
LSTALS IS CALLED BY : MAIN
LSTCGA IS CALLED BY : LSTSW1
LSTPRM IS CALLED BY : MAIN
LSTSW1 IS CALLED BY : LSTALS
LSTVVC IS CALLED BY : ANS0 ANS
LSTXYZ IS CALLED BY : LSTSW1
MAIN IS CALLED BY :
MLINE IS CALLED BY : BDS014
MOX IS CALLED BY : NOZMJ2 NOZKCC
MOMCAL IS CALLED BY : LSTALS
MSUM IS CALLED BY : BOUND
MUNUAR IS CALLED BY : F271 F271NO MRK001
MEWPG1 IS CALLED BY : INPRM RUNPRM VTXPRM VTXOUT BLDG11 BLDCT1 BLDG12 BLDG13 BLDCT3 LSTPRM
: VELORD LSTVVC VEL003 WAKPRM AIRPRM AIRDRG F104PE F271 MRK001 MRK010
: NOZPRM NOZCLC NOZSMS ANS0 ANS0NO ANS01 WAK002 LSTALS
NOISEX IS CALLED BY : MAIN
NOZAIR IS CALLED BY : NOZFFC NOZNFC
NOZAMP IS CALLED BY : NOZKCC
NOZBLC IS CALLED BY : NOZFFC NOZNFC
NOZCHK IS CALLED BY : NOZCLC
NOZCLC IS CALLED BY : NOISEX
NOZDPL IS CALLED BY : NOZFFC NOZNFC
NOZFFC IS CALLED BY : NOZCLC
NOZHFL IS CALLED BY : NOZMHF
NOZIMP IS CALLED BY : NOZCLC
NOZKCC IS CALLED BY : NOZCHK
NOZHPL IS CALLED BY : NOZFFC NOZNFC
NOZNFC IS CALLED BY : NOZCLC
NOZMHF IS CALLED BY : NOZHPL
NOZMJ2 IS CALLED BY : NOZCHK
NOZPRM IS CALLED BY : MAIN
NOZQPL IS CALLED BY : NOZFFC NOZNFC
NOZRD1 IS CALLED BY : NOZFFC NOZNFC
NOZSMS IS CALLED BY : NOZCLC
NOZTRP IS CALLED BY : NOZFFC NOZNFC
MRK001 IS CALLED BY : WAK003
MRK002 IS CALLED BY : MRK001
MRK003 IS CALLED BY : MRK002
MRK004 IS CALLED BY : MRK002
MRK005 IS CALLED BY : MRK002
MRK006 IS CALLED BY : MRK002
MRK007 IS CALLED BY : MRK002
MRK008 IS CALLED BY : MRK002
MRK009 IS CALLED BY : MRK003
MRK010 IS CALLED BY : WAK003
MRK011 IS CALLED BY : MRK010
PF1 IS CALLED BY : BDS014
PF2 IS CALLED BY : BDS014
PLTFF2 IS CALLED BY : INFFNS WINGIN
PLTFF0 IS CALLED BY : MRK008 MRK009 INF INFFN0
PRNTCD IS CALLED BY : F271 MRK001

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PRNTCS IS CALLED BY : LSTPRM
PRNTDP IS CALLED BY : LSTVVC VEL003 WAKPR1 F271
PRNTIN IS CALLED BY : BLDCT1 BLDCT3 LSTVVC VEL003 WAKPR1 AIRP02 F271
PRNTXX IS CALLED BY : RUNPRM VTXPRM BLDG11 BLDCT1 BLDG13 BLDCT3 LSTPRM VEL002 LSTVVC
: VEL003 WAKPRM AIRPRM AIRDRG AIRP02 NOZPRM LSTALS
PSIK2 IS CALLED BY : THICK
P1 IS CALLED BY : HRSUB
P2 IS CALLED BY : HRSUB
QSPLIN IS CALLED BY : VTXINP BLDCT1 LSTSW1
RADINT IS CALLED BY : BOUND
RJF IS CALLED BY :
RUNPRM IS CALLED BY : MAIN
R4ARAY IS CALLED BY : INFFNS WINGIN
SMWAK IS CALLED BY : BOUND
SMWAK0 IS CALLED BY : BOUND
SPCOEF IS CALLED BY : QSPLIN
SPECIN IS CALLED BY : IKSUB0
SPFUNC IS CALLED BY : QSPLIN
SPLSD3 IS CALLED BY : SPCOEF
SPLSEV IS CALLED BY : SPMVAL SPSVAL
SPMVAL IS CALLED BY : QSPLIN
SPSVL IS CALLED BY : QSPLIN
STARC IS CALLED BY : CASARF
SUM1 IS CALLED BY : WAKESN
SUM2 IS CALLED BY : WAKESN
SUM3 IS CALLED BY : WAKESN
SUM4 IS CALLED BY : WAKESN
SUM5 IS CALLED BY : WAKESN
SUM6 IS CALLED BY : WAKESN
SWPARF IS CALLED BY : AIRFLX
THICK IS CALLED BY : F271
THICK0 IS CALLED BY : THICK
THICK3 IS CALLED BY : THICK
TIKSUB IS CALLED BY : INF
TIK0 IS CALLED BY : INF
TRAP IS CALLED BY : F104PE
UNBAR IS CALLED BY : CLFACT DRAG24 DZROAL
UNINT IS CALLED BY : BLDCT1 BLDG12 BLDCT3 DZROAL STARC
UNLIN IS CALLED BY : NOZMHF
UVINT IS CALLED BY : BLDCT1 ANS0 ANS0NO LSTALS
VELORD IS CALLED BY : MAIN
VEL002 IS CALLED BY : VELORD
VEL003 IS CALLED BY : LSTVVC
VORTEX IS CALLED BY :
VORTW1 IS CALLED BY : LSTALS
VTXAUG IS CALLED BY : VTX001
VTXCD2 IS CALLED BY : VTX001
VTXCE IS CALLED BY : VTX001
VTXDB0 IS CALLED BY : VTX001
VTXDLE IS CALLED BY : VTX001
VTXINP IS CALLED BY : VTX001
VTXJEF IS CALLED BY : VTX001
VTXKST IS CALLED BY : VTX001
VTXNMT IS CALLED BY : VTX001 LSTALS
VTXOUT IS CALLED BY : VTX001
VTXPRF IS CALLED BY : VTX001
VTXPRM IS CALLED BY : MAIN
VTXWRD IS CALLED BY : VTX001
VTX001 IS CALLED BY : VORTEX LSTALS
WAKE IS CALLED BY : KMATRIX
WAKEQ0 IS CALLED BY : KMATRO

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Figure 35B Subroutine Cross References (continued)

WAKM0 IS CALLED BY : KMATR0
WAKM01 IS CALLED BY : WAKM0
WAKPRM IS CALLED BY : MAIN
WAKPR1 IS CALLED BY : F104PE WAK002
WAK001 IS CALLED BY : MAIN
WAK002 IS CALLED BY : WAK001
WAK003 IS CALLED BY : WAK002
WAK004 IS CALLED BY : WAK003
WING IS CALLED BY : BOUND
WINGF IS CALLED BY : WINGIN
WINGIN IS CALLED BY : WING
ZEROAL IS CALLED BY : CASARF
Z0DEF IS CALLED BY : MRK003 MRK006 THICK0 THICK5 BOUND0

LABEL COMMON AREA REFERENCE LISTING

SUBROUTINE	USES	: LABELED COMMON
AIRDRG	USES	: LSTR01 AIRP01 AIRDAT AIRCDF AIRCDM AIRALZ
AIRFLX	USES	: AIRDAT AIRCDF AIRCDM AIRALZ
AIROFF	USES	: AIRDAT AIRCDF AIRCDM AIRALZ
AIRPRM	USES	: AIRP01 DTETHE
AIRP02	USES	: AIRDAT AIRCDF AIRCDM AIRALZ
AIR24	USES	: AIRDAT AIRCDF AIRCDM AIRALZ
BDS014	USES	: BDS003 INDEX OUTPUT
BDS018	USES	: BDS001 BDS002
BESSAV	USES	: BESAR BESDEL
BLDCT1	USES	: BLDG01 CRPSR1 CRPSR2 BLDGEO
BLDCT3	USES	: BLDG03 BLDGEO
BLDGEM	USES	: DTETHE
BLDG11	USES	: DTETHE BLDG01 BLDGEO
BLDG12	USES	: DTETHE BLDGEO
BLDG13	USES	: DTETHE BLDG03 CRPSR1 CRPSR2 BLDGEO
BLDGP1	USES	: DTETHE BLDGEO
BSINT	USES	: BESAR BESDEL
BSJINT	USES	: BESAR BESDEL
BSYINT	USES	: BESAR BESDEL
CASARF	USES	: AIRDAT AIRCDF AIRCDM AIRALZ
DRA024	USES	: AIRDAT AIRCDF AIRCDM AIRALZ
F271	USES	: WORK WORK1
F271NO	USES	: WORK WORK1
GOS011	USES	: COM002
GOS107	USES	: COM002
HEADER	USES	:
INPTRM	USES	: DTETHE
ISOAFL	USES	: AIRDAT AIRCDF AIRCDM AIRALZ
ISOARF	USES	: AIRDAT AIRCDF AIRCDM AIRALZ KCLSAV
LIFT24	USES	: AIRDAT AIRCDF AIRCDM AIRALZ
LSTALS	USES	: PROVRS HEADR1 HEADR2 DTETHE WAKP01 WAKR01 BLDGEO V111C1 LSTR01 LSTR02
LSTALS	USES	: RMCP01 AIRP01 CRPSR1 CRPSR2 LSTR01 WORK WORK1
LSTPRM	USES	: DTETHE LSTR01 CRPSR1 CRPSR2
LSTSH1	USES	: HSQSPL
LSTVVC	USES	: LSTR01 CRPSR1 CRPSR2
MAIN	USES	:
NEWPG1	USES	: PROVRS DTETHE CRPSR1 CRPSR2 HEADR1 HEADR2
NOISEX	USES	: DTETHE
NOZCLC	USES	: NOZDAT NOZWRK
NOZFFC	USES	: NOZS16
NOZMFC	USES	: NOZS16
NOZPRM	USES	: NOZDAT
NOZSHS	USES	: NOZWRK
NRK001	USES	: WORK
OSPLIN	USES	: HSQSPL
RUNPRM	USES	: DTETHE RMCP01
SNPARF	USES	: AIRDAT AIRCDF AIRCDM AIRALZ
VELGRD	USES	: V111C1 CRPSR1 CRPSR2
VEL002	USES	: V111C1
VORTEX	USES	: DTETHE
VTXINP	USES	: HSQSPL
VTXPRM	USES	: VTXCOM
VTX001	USES	: VTXCOM
WAKPRM	USES	: DTETHE CRPSR1 CRPSR2 WAKP01
WAKPR1	USES	: WAKR01
WAK001	USES	: WAKR01 WAKP01 LSTR02 LSTR01 DTETHE

WAK003	USES	: WORK
ZEROAL	USES	: AIRDAT AIRCDF AIRCDM AIRALZ

Figure 36 Common Area References

LABELED COMMON AREA CROSS REFERENCE LISTING

LABEL

SUBROUTINE

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IS USED BY : MAIN HEADER
AIRALZ IS USED BY : AIRDRG AIRP02
AIRALZ IS USED BY : AIRFLX AIROFF AIR24 CASARF DRAG24 ISOAFL ISOARF LIFT24 SHPARF ZEROAL
AIRCDF IS USED BY : AIRFLX AIROFF AIR24 CASARF DRAG24 ISOAFL ISOARF LIFT24 SHPARF ZEROAL
AIRCDF IS USED BY : AIRDRG AIRP02
AIRCDM IS USED BY : AIRDRG AIRP02
AIRCDM IS USED BY : AIRFLX AIROFF AIR24 CASARF DRAG24 ISOAFL ISOARF LIFT24 SHPARF ZEROAL
AIRDAT IS USED BY : AIRFLX AIROFF AIR24 CASARF DRAG24 ISOAFL ISOARF LIFT24 SHPARF ZEROAL
AIRDAT IS USED BY : AIRDRG AIRP02
AIRP01 IS USED BY : AIRPRM AIRDRG LSTALS
BDSC01 IS USED BY : BDS010
BDSC02 IS USED BY : BDS010
BDSC03 IS USED BY : BDS014
BESAR IS USED BY : BESSAV BSINT BSJINT BSVINT
BESDEL IS USED BY : BESSAV BSINT BSJINT BSVINT
BLDGE0 IS USED BY : BLDG11 BLDCT1 BLDG12 BLDGP1 BLDG13 BLDCT3 LSTALS
BLDGE1 IS USED BY : BLDG11 BLDCT1
BLDGE3 IS USED BY : BLDG13 BLDCT3
COM002 IS USED BY : GGS011 GGS107
CRPSR1 IS USED BY : NEWPG1 BLDCT1 BLDG13 LSTPRM VELGRD LSTVVC WAKPRM LSTALS
CRPSR2 IS USED BY : NEWPG1 BLDCT1 BLDG13 LSTPRM VELGRD LSTVVC WAKPRM LSTALS
DTETHE IS USED BY : WAKPRM AIRPRM NOISEX WAK001 LSTALS
DTETHE IS USED BY : INPTRM NEWPG1 RUNPRM VORTEX BLDGEM BLDG11 BLDG12 BLDGP1 BLDG13 LSTPRM
HEADR1 IS USED BY : NEWPG1 LSTALS
HEADR2 IS USED BY : NEWPG1 LSTALS
HSOSPL IS USED BY : VTXINP QSPLIN LSTSH1
INDEX IS USED BY : BDS014
KCLSAV IS USED BY : ISOARF
LSTP01 IS USED BY : LSTPRM LSTALS
LSTR01 IS USED BY : LSTVVC AIRDRG WAK001 LSTALS
LSTR02 IS USED BY : WAK001 LSTALS
NOZDAT IS USED BY : NOZPRM NOZCLC
NOZS16 IS USED BY : NOZFFC NOZMFC
NOZWRK IS USED BY : NOZCLC NOZSMS
OUTPUT IS USED BY : BDS014
PROVRS IS USED BY : NEWPG1 LSTALS
RNCPR1 IS USED BY : RUNPRM LSTALS
VTXCOM IS USED BY : VTXPRM VTX001
V111C1 IS USED BY : VELGRD VEL002 LSTALS
WAKP01 IS USED BY : WAKPRM WAK001 LSTALS
WAKR01 IS USED BY : WAKPR1 WAK001 LSTALS
WORK IS USED BY : F271 F271NO MRK001 WAK003 LSTALS
WORK1 IS USED BY : F271 F271NO LSTALS

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Figure 37

Common Area Cross References

1. Report No. NASA CR 185194		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Unified Aeroacoustics Analysis for High Speed Turboprop Aerodynamics and Noise Volume IV - Computer User's Manual for UAAP Turboprop Aeroacoustic Code				5. Report Date May 1991	
				6. Performing Organization Code	
7. Author(s) R. W. Menthe, C. J. McColgan, and R. M. Ladden				8. Performing Organization Report No. None	
				10. Work Unit No. 535-03-01	
9. Performing Organization Name and Address Hamilton Standard Division United Technologies Corporation PO Box 1000 Windsor Locks, CT 06096				11. Contract or Grant No. NAS3-23720	
				13. Type of Report and Period Covered Contractor Report Final	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191				14. Sponsoring Agency Code	
15. Supplementary Notes Project Manager, Bruce Clark, Advanced Turboprop Project Office, NASA Lewis Research Center, Cleveland, Ohio 44135					
16. Abstract This report presents a unified theory for aerodynamics and noise of advanced turboprops. Aerodynamic topics include calculation of performance, blade load distribution, and non-uniform wake flow fields. Blade loading can be steady or unsteady due to fixed distortion, counter-rotating wakes, or blade vibration. The aerodynamic theory is based on the pressure potential method and is therefore basically linear. However, non-linear effects associated with finite axial induction and blade vortex flow are included via approximate methods. Acoustic topics include radiation of noise caused by blade thickness, steady loading (including vortex lift), and unsteady loading. Shielding of the fuselage by its boundary layer and the wing are treated in separate analyses that are compatible but not integrated with the aeroacoustic theory for rotating blades. The report is in 5 volumes with titles and contractor report numbers as follows. <div style="display: flex; flex-direction: column; padding-left: 20px;"> <div>Volume I. "Development of Theory for Blade Loading, Wakes, and Noise", (CR 4329)</div> <div>Volume II. "Development of Theory for Wing Shielding", (CR 185192)</div> <div>Volume III. "Application of Theory for Blade Loading, Wakes, Noise, and Wing Shielding", (CR 185193)</div> <div>Volume IV. "Computer User's Manual for UAAP Turboprop Aeroacoustic Code" (CR 185194)</div> <div>Volume V. "Propagation of Propeller Tone Noise Through a Fuselage Boundary Layer", (CR 185195)</div> </div>					
17. Key Words (Suggested by Author(s)) Prop-Fan, High Speed Turboprop, Aerodynamics, Noise, Acoustic Shielding, Vortex Lift, Unsteady Lift, Wakes				18. Distribution Statement General release	
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No of pages 119	
				22. Price*	

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